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PACIFIC OCEANIC FISHERY
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OF THE

UNITED STATES FISH COMMISSION.

VOL. I,

FOR

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UNITED STATES COMMISSION OF FISH AND FISHERIES,
Washington, D. C.

For the purpose of utilizing and of promptly publishing the large amount of interesting correspondence of the Fish Commission in reference to matters pertaining to fish culture and to the apparatus, methods, and results of the fisheries, Congress, on the 14th day of February, 1881, by joint resolution (H. Res. 372), authorized the publication annually of a Bulletin, a portion of the edition to be distributed signature by signature, and the remainder in bound volumes. The present volume is the first of this series, and contains many announcements which are believed to be of great importance in relation to the subject in question.

SPENCER F. BAIRD,
Commissioner.

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BULLETIN

OF THE

UNITED STATES FISH COMMISSION.

1881.

GILL-NETS IN THE COD-FISHERY: A DESCRIPTION OF THE NORWEGIAN COD-NETS, WITH DIRECTIONS FOR THEIR USE, AND A HISTORY OF THEIR INTRODUCTION INTO THE UNITED STATES.

By CAPT. J. W. COLLINS.

[TWELVE PLATES.]

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A.—INTRODUCTION.

Although gill-nets have long been used in Norway as an apparatus for the capture of cod, and are considered quite indispensable by the fishermen of that country, they have never until recently been introduced into the United States. In 1878 Prof. Spencer F. Baird, Commissioner of Fisheries, knowing how profitably these were employed by the Norwegian fishermen, decided to make experiments with them at Cape Ann, with a view to their introduction among the cod-fishermen of this country. He accordingly secured a set of the Norwegian nets, which were sent to Gloucester and there tested by the employés of the Commission.

Experiments were made when the winter school of cod were on the shore grounds, but the results obtained were not entirely satisfactory, owing chiefly to the fact that the nets were found far too frail for the large cod which frequent our coast in winter. This was apparent from the numerous holes in the nets, which indicated plainly that large fish had torn their way through, none being retained excepting those that had become completely rolled up in the twine. The current also swept them afoul of the rocky bottom, which injured them still more, so that they were soon rendered nearly unfit for use. The nets were invariably in bad order when hauled from the water, but even under such unfavorable circumstances nearly a thousand pounds were caught on one occasion. This seemed to indicate that nets of sufficient strength might be used to good advantage, at least on some of the smoother fishing grounds, along the coast and on the outer banks.

These preliminary trials, therefore, having demonstrated that nets could be used to good advantage in the American cod-fisheries, Professor Baird availed himself of the first chance that offered for obtaining definite knowledge of the methods of netting cod in Norway, with the intention of disseminating this information among American cod-fishermen.

The opening of the International Fishery Exhibition at Berlin, Germany, in the spring of 1880, presented a favorable opportunity for accomplishing this purpose. Professor Baird having appointed the writer as one of the commission to attend the exhibition on the staff of Prof. G. Brown Goode, desired that a careful study should be made by him of the foreign methods of deep-sea fishery as represented at the exhibition. The method of capturing cod with gill-nets, as practiced by the Norwegian fishermen, was mentioned as a subject which should receive especial consideration, and it was suggested that it might even be desirable to visit Norway, so that the practical operation of this fishery might be observed.

It is probable, however, that the information on this subject that has been obtained at the exhibition and elsewhere will be sufficient to enable our fishermen to use gill-nets for cod with success.

It was the original intention of Professor Baird that a report of the observations made at the Berlin exhibition should be published as soon after the return of the commissioners as possible, but circumstances delayed for a time its preparation.

The use of gill-nets in the cod-fisheries at Ipswich Bay the present winter—an account of which will be given—has resulted in complete success, and there is strong probability that they will be introduced into the bank-fisheries, as well as those along the coast; therefore, Professor Baird has suggested the preparation of this pamphlet by the writer, and it is hoped that it may serve the purpose for which it is intended, by supplying information that may lead to the more profitable prosecution of the American cod-fisheries.

Acknowledgments are due to Mr. Frederik M. Wallem, the Norwegian Commissioner to the Berlin exhibition, for information furnished concerning the gill-nets and their use in the Norwegian cod-fisheries. The account of the Newfoundland cod gill-nets, methods of fishing, &c., is given largely on the authority of Capt. Solomon Jacobs, of Gloucester, Mass., who is a native of Newfoundland, and has had considerable experience in the cod-fisheries along the east coast of that island.

B.—CONSTRUCTION AND RIG OF THE NETS.

1.—Norwegian methods.

The nets used in the Norwegian cod-fisheries are usually made of hemp twine, of two, three, or four threads, but occasionally of flax or cotton. The three-layed hemp twine, which is the most common size, weighs a pound to 400 or 420 fathoms. It is mostly spun on the spinning wheel by the fishermen's families, and the nets are almost exclusively made by the fishermen and their wives and children. Some of the hemp twine, however, is furnished by the factories of Norway and Great Britain, which also supply all of the cotton and linen twine.

The size of the mesh varies somewhat, according to the locality where the nets are to be used, as it is necessary to make the mesh correspond to the size of the fish that frequent different parts of the coast, or make their appearance at different seasons. The smallest mesh is about $5\frac{2}{5}$ inches ($2\frac{7}{10}$ inches square) and the largest 8 inches (4 inches square). Those exhibited at Berlin were 7 and 8 inch mesh.

The length of the nets varies from 10 to 20 fathoms, the average length of those used at the Lofoten Islands being $15\frac{1}{4}$ fathoms, when hung, and they are from twenty-five to sixty meshes deep. Nets about thirty meshes deep are generally used, while those of sixty meshes are employed only where there is little or no current. The nets are hung both to single and double lines, and these vary somewhat in size. Those ex-

hibited were hung to double lines, each being $\frac{1}{10}$ of an inch in circumference, while Mr. Wallem says that 2-inch rope when single, and 1-inch rope when double, is the size commonly used at the Lofoten Islands. Some of the nets are hung to lines only at the top and bottom, having none across the end, while others have them on the ends as elsewhere. This last method is said to have been recently introduced, and is considered an improvement when the line is a little short, so that the net will be a trifle slack or baggy. About one-third of the net is taken up in hanging; that is, if a net is 30 fathoms long, stretched out, before it is hung, it will be about 20 fathoms long afterwards. They are hung with twine about the same size as that of which they are made. The end of the twine is first made fast to the hanging line, then hitched to the upper part of one of the meshes, the distance between the line and mesh being equal to one side of the mesh; then back to the line again, around which a clove-hitch is taken, thus forming one-half of a mesh, as shown in Plate I. This method of hanging is thought by the Norwegian fishermen to be superior to any other for large-mesh nets. They are generally prepared for use in Norway by tanning, and will last, when so prepared, from one to five seasons.

The nets are supported upright in the water by floats of wood, cork, or hollow glass. At the Lofoten Islands, where nets are more extensively used than elsewhere, the glass floats are preferred, it being said that they replace to great advantage the old wooden ones, which failed to prevent the nets from settling on the bottom. The fishermen from Söndmör, however, who fish on banks where there is a strong current, prefer wooden to glass floats, since, it is said, the latter are so much more easily carried away by the tide, causing the loss of many nets; while the principal objection to wooden floats is that they are so easily waterlogged. But this is thought to be the lesser evil of the two, since they can, at the worst, only sink to the bottom with the nets, whence they may easily be recovered. From this experience of the Norwegian fishermen, it may be inferred that while glass floats are preferable for general use, they are not so suitable as either wood or cork buoys where there is a strong tide. The glass floats are about 5 inches in diameter, with a covering of tarred marlin or spun-yarn hitched over them, to which is attached an eye. In this eye is bent the small rope that holds them to the net. When so prepared for use these floats are quite strong, and break far less frequently than might be supposed. They withstand the pressure of water when submerged better than anything that has been tried, but are sometimes filled with water—"drunken," it is called—when set in deep water. Plate II is intended to show the glass float and the way in which it is attached to the net. The small ropes with which these are held vary in length from 1½ to 6 feet.

Oblong-shaped stones, from 3 to 5 inches in length, are used for sinkers. By experience the fishermen learn how large these should be to sink the nets to the desired depth. From ten to twelve are fas-

tened to the bottom of the net at equal distances apart, being held in a double string, as shown in Plate III.

Large stones are used instead of anchors to hold the nets to the bottom. These weigh from 72 to 144 pounds, the heavier one heading the current, and the smaller being on the other end of the gang, containing twenty to thirty-five nets. Besides these "mooring rocks," there are others of smaller size that are held to the nets by a foot-line, one end of which is fastened to the stone which lies on the bottom, and the other to the rope that connects the lower part of the nets together. The larger stones are generally slung with rope, but sometimes with a band of iron around them, with an eye or ring to which the foot-line can be fastened. Iron anchors are not used, as the nets are liable to be torn on them should they settle on the bottom. Plates VI and VII show how the mooring rocks and the other stones are attached to the nets.

Buoys of different kinds are used by the Norwegian fishermen, but, according to Mr. Wallem, at the Lofoten Islands glass buoys, having a capacity of about three to five gallons, are the most common. These are generally egg-shape and are covered in the same manner as the glass floats. Sometimes a buoy is made by fastening several of the latter around a staff, as shown in Plate X. The glass buoys, of both kinds, are employed in the trawl as well as the net-fishery; they will rise to the surface again after having been under water for several days, an advantage not possessed by other kinds, and it seems that buoys of this description might be profitably used by our bank-fishermen, who frequently lose large quantities of gear on account of the wooden ones bursting and filling with water when they are submerged to any considerable depth. Hard-wood, iron-bound kegs are used by some of the Norwegian net-fishermen. From two to four glass floats, such as are on the nets, are fastened to the bight of the buoy-line, at different distances from the buoy, for the purpose of keeping the slack or scope from going on the bottom when there is no current. Where there is a strong tide, and a probability of the large buoy being drawn under the surface of the water, a number of the glass balls are attached to it with a line, these serving as "watch-buoys" for the other. Plate V shows how the glass floats are fastened to the buoy-line and buoy.

2.—Newfoundland methods.

The nets employed in the Newfoundland cod-fisheries are usually made of hemp twine one size smaller than salmon-twine, which is also occasionally used. The size of the mesh is generally about 6 inches (3 inches square), a large mesh not being required for the small fish that frequent that coast. The nets vary in length from 50 to 80 fathoms, and in depth from 3 to 4 fathoms. They are hung to the lines in the same way that the Norwegian nets are, the foot-line being 1¼-inch rope, while small-sized double lines, of opposite lays, are the hangings for the top and ends. Rope is used on the lower part of the net, because,

when set close to the bottom, small line would probably be bitten off by ground-sharks, thereby causing the loss of a portion of the net.

To preserve the nets the Newfoundland fishermen make a mixture of tan and tar, which is thought better than either used separately. The tan is commonly made from spruce buds, fir bark, and birch bark (hemlock bark is not used), which are boiled together until it is sufficiently strong, when the bark is removed, and tar added in the proportion of five gallons of tar to two hundred gallons of tan, the whole being stirred well together. Some care is necessary in applying this, or else it will not be evenly distributed on the net. The custom of mixing tan and tar has doubtless been introduced from England, as it is known that the Cornish fishermen do this, pouring out their tanning liquor into large vats with coal tar, and this mixture is found to preserve the nets much longer than simple tanning. The Newfoundland nets, when prepared in this manner, generally last about four seasons.

The floats are made of the best bottle-cork, when obtainable. Before being used they are dipped in hot pitch or tar, after which it is said they will stand for four weeks at the bottom in 50 fathoms before getting water-soaked. The fishermen have two sets of floats—one, when soaked, being replaced by the other.

The sinkers most generally in use by the Newfoundland fishermen are made by tying small rocks in a bag of old netting or cloth; but lead sinkers, similar to those on seines, are occasionally attached to the nets. The sinkers weigh from 1 to 2 pounds, are about 13 feet apart, and are fastened close to the bottom of the net.

Anchors, rocks, and stone killicks are used for moorings to the nets. The former weigh from 20 to 25 pounds each, while the killicks and rocks vary from 25 to 60 pounds, the heavier heading the current, and the lighter being on the opposite end of the net or gang.

The buoys are generally made of dry fir poles, 6 to 8 inches in diameter, are usually from 3 to 4 feet long, and sharpened at one end, through which is a hole for the strap that the buoy-line bends to. Kegs are also used for buoys.

3.—American methods.

The nets that were first tried in Ipswich Bay were made of twine about the same size as that used in Norway; indeed, part of them were Norwegian nets that had been lent to Captain Martin by the United States Fish Commission. These were found, as in the previous trials made by the Commission, entirely too weak for the purpose, and were soon badly torn, not, however, before it had been proved that suitable nets could be very successfully used. The nets that have since been constructed for this fishery are made of Scotch flax twine, twelve-thread, of the size represented in Plate IV. The twine is very strong, and is found to be well adapted for the capture of large cod. The nets are 9 inch mesh (4½ inches square), that size having been found well adapted

for taking the large winter cod in that locality. Smaller-meshed nets are, however, being prepared for the bank and summer shore-fisheries.

The size of the nets depends somewhat on the locality where they are used, and also on the movements or habits of the fish. In some places where the cod keep close to the bottom, long shoal-nets are probably the most suitable, while at other points, as at the Lofoten Islands, where they are often found in the greatest numbers some distance from the bottom, deeper nets are required.

The nets made for Captain Martin were 50 fathoms long and 3 fathoms deep, but as nearly all the fish were caught near the bottom, other parties have since had shoaler and longer nets; the most of those lately made for the shore-fleet are 100 fathoms long and 2 deep.* These are hung to small double lines of opposite lays, and they are tanned before being used. It may be well to mention here the Dutch method of tanning cotton herring-nets, which is thought better than any other by those foreign fishermen, and may, perhaps, be applied with equal advantage to other nets, when made of that material. The tan is made by boiling catechu in water in the proportion of one pound of the former to two and a half gallons of the latter. When it is sufficiently strong the nets are soaked in it for twenty-four hours, after which they are dried. They are tanned and dried three times, and then soaked in linseed oil. A pound of oil is provided for each pound of net, and they are allowed to remain in it as long as any will be absorbed. They are then well drained and spread out on the ground to dry, after which the process is completed by tanning them once more.

Glass floats, similar to those of Norway, have been used on the American nets.† These cost about 30 cents each, when covered, and twenty-five of them are attached to a 50-fathom net. Bricks are used for sinkers, one of which is fastened to the foot of the net directly beneath each of the floats, they being held in the same manner that the stone sinkers are, as shown in Plate III. It is probable that suitable metal sinkers may soon be devised, and perhaps desirable improvements may be made in the floats as well. The cost of nets 50 fathoms long, with floats attached, is about $18.

Fourteen-pound trawl-anchors have been found quite suitable for Ipswich Bay, one being attached to each end of a gang of three nets, but it is quite probable that heavier ones will be required where there is deeper water and more current.

The buoys are common quarter-barrels, rigged in the same manner as for trawling.

* These nets have been principally made by the American Net and Twine Company, and H. & G. W. Lord, Boston, Mass.

† These are made at the glass factories in Boston.

C.—THE FISHERIES.

I.—The Norwegian fisheries.

The method of taking cod with gill-nets is said to have been introduced into Norway about 1685, and nets are now employed extensively at the principal fishing stations along the coast of that country, but more than anywhere else in the great winter cod-fisheries that are carried on at the Lofoten Islands. These islands are situated on the west coast of Norway, north of the Arctic circle, and the banks in their vicinity are the favorite resort of immense schools of cod that gather there to spawn. Toward the latter part of December the first schools appear upon the grounds along the outer side of the Lofoten group, and soon the "coming-in" fish are taken on those banks lying inside, in the Westfiord. The arrival of these fish, which are the forerunners of the countless millions that invariably follow, is hailed with great delight by the fishermen, many of whom resort hither from other parts of the country to engage in these fisheries, so many often being congregated here in the winter that at some points they are quite crowded.

The bank which is the principal resort of the fishermen from Nordland extends along the coast of Lofoten from the island of Röst to the Strait of Raft. This is from three to twelve miles from the land, and has a depth varying from 40 to 80 fathoms.

The fishing is at its height in February and March, while the fish are spawning. At this period, especially during the latter month, the cod are said to be very restless and disinclined to take the hook, and are usually caught in nets, the catch being increased and a better quality of fish obtained by using them. The experience of the Norwegian fishermen shows that the fatter the fish the less it is inclined to take the bait; therefore the most skillful fishermen are provided with nets as well as trawls.

The fishing is carried on in open boats. The net-boats, which, as a rule, are larger than those used for trawling, are from 35 to 40 feet long, 9 to 10 feet wide, and 3 feet deep. These are provided with a single mast, on which is set a large quadrangular sail, and each boat has also ten or twelve oars, by means of which the crew can row rapidly even against the wind. The crew of a boat fitted for the net-fishery varies from six to eight men, and the number of nets from sixty to a hundred. These are not all in use at the same time, but the greater part are kept in reserve to supply the place of such as may need repairs or drying, or that may be lost. From twenty to thirty-five nets are fastened together and set in a gang by each boat on a specified part of the fishing ground. Where so many are fishing at one place they are obliged to adopt some rule for setting the gear to prevent its fouling, since that would result in loss to all and soon render a valuable fishery practically worthless. A certain part of the fishing ground is therefore assigned for the nets, and an-

other part for the trawls, as it is evident they should not be set together. The nets are prepared for setting by fastening them together at top and bottom, attaching the sinkers, and bending on the large anchor-stones in the manner already alluded to, and which is shown in Plates V, VI, and VII. The nets are so arranged that they will set close to the bottom or some distance above it, according to the position of the fish.

The cod in the vicinity of the Lofoten Islands are said to be somewhat erratic in their movements, and it frequently happens that they are found in the greatest numbers quite a distance from the bottom. The fishermen therefore set their nets at a depth where they think the fish are most plentiful, and several expedients are resorted to to find this out, such as trying with a hand-line, and setting a gang of nets with one end at the bottom and the other some distance from it, as represented in Plate VI.

Nets are occasionally set floating, but this method of setting is practiced but little except at the stations east of Sorvaagen. One experienced in fishing soon learns at what depth the most fish can be taken, and places his apparatus accordingly.

The fishermen all start in the afternoon at a given signal to set their gear, both nets and trawls being thrown out simultaneously to prevent them from becoming tangled, though this is sometimes unavoidable on account of the strong winds and tides. The nets are set with or across the current. As soon as they are out the boats return to the shore.*

At the Lofoten Islands the fishermen start out together in the morning to haul their nets; in the darkness of the long nights they enter their boats, for the brief daytime, often shortened by gloomy skies, would be far too short for the work which has to be accomplished. They regard neither cold nor storm as long as the waves are not too high, so as to make fishing impossible. Hauling the heavily weighted nets, sometimes from a depth of 80 to 100 fathoms, is a task requiring the united strength of the boat's crew. The nets are hauled into the boats and taken on shore, where they are cleaned and put in readiness to be set again. But it must be remembered that in this region stormy weather often continues for weeks at a time during the winter months, making it impossible for the fishermen to go out to the banks, and as a rule fishing cannot be carried on more than two days in the week.

The daily fishing varies from a few scattering cod to several hundreds. A catch of four to five hundred to a boat is considered very satisfactory, although six hundred are often taken when everything is favorable, even when they will not bite, and lines or trawls cannot be used. If more than six or eight hundred are caught, the fishermen are obliged to leave a part of the nets out until afternoon, as the boats can rarely carry any more, especially in rough weather.

*At Söndmör, where the banks lie some distance from the coast, the fishermen sometimes stay out over night during the month of April, when the nights have already become quite clear. Usually, however, these men haul their nets and return them again to the water, while they start for the shore to dispose of their catch.

The total catch of cod at the Lofoten Islands in 1878, according to the report of the superintendent, was 24,660,000 in number. Of these, upwards of 14,000,000 fish were caught with nets, 9,250,000 with lines, and 1,250,000 with deep bait.* The men and boats engaged were divided as follows:

	Fishermen.	Crews.	Boats.
Net-fishing	13,168	2,154	*2,430
Line-fishing	7,258	1,689	1,977
Deep-bait fishing	2,297	844	†844
Hired men	3,311	.....	.....
Total	23,034	4,687	5,251

*269 of these also occasionally used lines. †701 of these used no lines, and 143 used lines.

There was an *increase* from the year before of 2,542 in the number of net-fishermen, an *increase* of 417 in the number of deep-bait fishermen, and a *decrease* of 1,504 in the number of line-fishermen.

Highest total sum earned by net-fisherman	$214 40
Lowest total sum earned by net-fisherman	48 24
Highest total sum earned by line-fisherman	120 60
Lowest total sum earned by line-fisherman	32 16
Highest total sum earned by deep-bait fisherman	85 76
Lowest total sum earned by deep-bait fisherman	42 88

The superiority of the nets over lines and trawls, as shown by the respective earnings of the fishermen, has, as might be expected, led to an additional increase in that branch of the fishery, and in 1879 it is stated that 2,532 boats, with crews numbering 14,322 men, fitted out for the net-fishery. The larger amount earned by the net fishermen is due to the better quality of fish taken by them more than to the increased catch, though this is also generally obtained. It has been found that the largest and fattest cod do not bite at the hook, but must be sought after with gill-nets, and it therefore follows that netted fish furnish a very superior article of merchandise. It sometimes requires but 210 cod caught in a net against 360 taken on a hook to furnish the same amount of liver, about 26½ gallons, and the livers of the netted fish yield much more oil to the gallon than those of the trawl of line fish. In conclusion, it may be added that pollock are taken in gill-nets as well as cod. During the winter season large schools of these fish visit the coast between the sixtieth and sixty-second parallels of latitude, and in the summer and fall are found on the coasts of Nordland and Finmark, where enormous quantities of them are taken by nets, trawls, and hand-lines.

2.—The Newfoundland fisheries.

Gill-nets have long been used in the Newfoundland cod-fisheries, especially on the east and south coasts of the island, but the exact date of

*Trawls are probably meant by lines, and hand-lines by deep bait.

their introduction is unknown. It is asserted, however, that this method of fishing has been pursued since early in the present century, and is still carried on to some extent.

The coast of Newfoundland is indented with many large bays, which are favorite feeding grounds for the cod. In the early summer they make their appearance in pursuit of the capelin that gather in immense numbers along the shores to spawn, and generally remain from three to five weeks. During this time the cod usually keep near the surface of the water and the nets are set floating, but later they are set at the bottom, for when the capelin leave the shores the cod move into deeper water. Plates VIII and IX show the methods of setting at the surface and bottom. The nets are set singly or in gangs of three to seven. Two anchors are generally attached to a gang of floating nets, as represented in the plate, but where there is a current one is sometimes found sufficient. They are usually set in the afternoon and hauled in the morning. Owing to the comparative lightness of the anchors, fewer men are required to haul these than in Norway, as a single fisherman will sometimes take in one or more nets, though in most cases two or three go in a boat. The net-fishing is far less productive than that of Norway, but sometimes a large catch is made. Captain Jacobs states that on one occasion he took from four nets 2,000 cod, but says that this is rarely equaled. These fish are what are known in the American markets as medium cod.

3.—The American fisheries.

Mention has been made of the introduction and trial of cod gill-nets by the United States Fish Commission in 1878, but no attempt was made by the fishermen to use them until the fall of 1880, when Capt. George H. Martin, of Gloucester, Mass., master of the schooner Northern Eagle, fitted out with them for the winter cod-fisheries off Cape Ann and in Ipswich Bay. The immediate cause which led to this trial was the difficulty of procuring a supply of bait, which is a source of considerable trouble to our shore-fishermen, and its cost, even when obtainable, is such a heavy tax on this branch of the fishing industry that often the fishermen hesitate to engage in it, fearing that it may result in loss rather than gain. It was to obviate this difficulty about bait, and to render our cod-fisheries more valuable in consequence, that led Professor Baird to bring the cod gill-nets to the notice of the American fishermen. The bait principally depended on by the shore-fishermen in the vicinity of Cape Ann, during the fall and early winter, is young herring (*Clupea harengus*), known as the "spirling." The appearance of these fish about the cape is somewhat uncertain; sometimes large schools remain for several weeks, and at other times but few can be taken. There was so little probability of getting a supply of bait in the fall of 1880 that Captain Martin hesitated about fitting out, fearing that the cost and difficulty of securing a supply of this article, which is indispensable to the trawl-

fishery, would render the undertaking profitless. While the matter of fitting out was under consideration, gill-nets were suggested by the father of Captain Martin, an employé of the Fish Commission, as a means to solve the perplexities of the bait question. He thought the idea a good one, and, together with several of his crew, visited the station of the Commission at Gloucester, looked at the Norwegian nets that were there, and consulted with the agent in charge as to the probabilities of success and the methods of fishing with them. The result of this interview was that he decided to fit out and give them a thorough trial, and nets were therefore obtained for this purpose, part of them being supplied by the Fish Commission. Before the trial trip was made, the writer met him in Gloucester, and briefly explained the Norwegian methods of using the nets. It was thought, however, by Captain Martin, that they might be "underrun," as trawls are sometimes, which would enable one man to handle a gang of nets for which an entire boat's crew, six to eight men, is required in Norway.

Ipswich Bay, where the nets have been tried the present winter (1880–'81), lies north of the prominent headland of Cape Ann, which divides it from the waters of Massachusetts Bay on the south. A sandy beach extends along the northern and western sides of the bay, and the bottom sinks gradually from this, only reaching a depth of 25 to 30 fathoms at a distance of several miles from the land. The bottom of the bay is a vast sandy waste, with only here and there small patches of rocks or clay, supporting but a small amount of animal life that may serve as food for the cod. It is therefore a spawning rather than a feeding ground for these fish, and large schools visit the bay for this purpose during the winter, generally remaining until late in the spring. The nets are usually set along the northern part of the bay, but a few miles from the shore, in about 15 fathoms of water, where there is less current than at some points along the coast. They have been found much less liable to chafe than trawls, the latter being badly damaged during a storm, while the former, which were suspended by the floats, were not injured.

The common dory has been used for fishing the nets, each vessel having from seven to nine of them, according to the number of the crew. The men go singly, one in each dory, and, while out, either setting or underrunning, the vessel is kept under way, the captain and cook managing her and picking up the crew when the work is completed. Each one of the Northern Eagle's crew, except the captain and cook, is provided with a gang of three nets, which are fastened together at top and bottom when set, these forming a wall at the bottom of the sea 150 fathoms long and 3 fathoms deep, being held in position by an anchor at either end. The anchor-lines are 50 fathoms in length, and one end of each is bent to the upper corner of the nets, as represented in Plate XI.

Under favorable circumstances one man can set a gang of nets, by

letting the boat drift with the wind or tide and throwing them over as it moves along, but, as a general rule, two men can accomplish this much better. When setting for underrunning, the anchor is first thrown over, and 25 fathoms of the line paid out, when the buoy-line is bent to it.* The buoy and line are then thrown over, and the remainder of the anchor-line, the end of the latter being made fast to the nets, which are the next to follow. A middle-buoy is attached to the center of the gang. When the nets are all out, the other anchor-line, with the buoy-line attached, is veered out, and last of all the anchor is thrown over, which finishes the work. The nets are usually set in the afternoon, and allowed to remain setting for several days, unless for some reason the vessel leaves the fishing ground. Even then, when forced to seek the shelter of a harbor during a storm, they have sometimes been left out. The distance at which the gangs of nets are set apart is said to be about 40 fathoms, but this is a matter to which no rule can be applied, as surrounding circumstances will cause many variations. But few fish are caught except at night, and, consequently, the nets are underrun only in the morning, unless the men are detained by the weather until later in the day. In underrunning, the fisherman goes to one of the buoys on the end of his gang of nets, takes it in the dory, and hauls away on the buoy-line, the buoy being thrown out on the other side and the line allowed to run out on one side as fast as it is hauled in on the other. When the anchor-line (underrunning line, as it is sometimes called) is up, it is taken across the dory, and the fisherman hauls along towards the nets. These are underrun by pulling them in one side of the dory, and, as fast as the fish are removed, allowing them to pass over the other side into the water, the anchors, which remain firmly fixed in the bottom, holding them in position until the work is accomplished. When the end of the gang is reached it is thrown off the dory, and the nets remain setting as before, needing no further attention until the next day. When underrunning they may be taken across either the forward or after part of the dory, as circumstances may require. Both of these methods are represented in Plate XII.

The time occupied in underrunning depends somewhat on the smoothness of the sea, but more particularly on the amount of fish taken. When the catch does not exceed more than 4,000 to 5,000 pounds to the vessel, it is done in about two hours, but when 15,000 to 18,000 pounds are caught, about four hours are required.

The success that has resulted from the use of nets in Ipswich Bay has been quite remarkable, the catch being much more than that of the trawlers fishing on the same ground. The amount taken for the first three trials, with unfavorable weather and with inferior nets, was 4,000, 6,000, and 7,000 pounds, respectively.

On a trip ending January 11, 35,000 pounds of cod were taken by the

* It is probable that a better way would be to fasten the buoy-line to the upper corner of the net where the end of the anchor-line is attached.

Northern Eagle, 8,000 pounds of which were caught in a single morning. Two other vessels, which were absent the same length of time, fishing at the same place with trawls, got only 4,000 and 8,000 pounds, respectively. Since that time she has made another trip, taking the same amount, 35,000 pounds, in four days' fishing, 18,000 pounds of which were caught in one day. On this day the schooner Christie Campbell, of Portsmouth, set ten trawls (each trawl having 1,000 hooks) close to the nets. The 10,000 hooks caught about 2,000 pounds of fish to the 18,000 taken in the nets.

Captain Martin began fishing with the nets November 27, 1880, and up to the 20th of January, 1881, had caught 111,000 pounds of cod. None of the trawlers took more than one-third of that amount, though fishing at the same place. The netted fish are larger than those caught on trawls, averaging, during the first six weeks' fishing, 23 pounds each. Among these were individuals which weighed 75 and 80 pounds apiece, but no small fish, such as are frequently taken on trawls, and can be sold only at a reduced price. In addition to the advantages already mentioned, no bait is, of course, required for net-fishing, and not only is the expense for this article saved, but the loss of time and trouble incident to securing it and also to baiting trawls is dispensed with. In consideration of these facts it is not strange that quite a lively interest has been manifested in the fishing communities, and that many vessels, both of the shore and bank fleet, are being supplied with this kind of apparatus for the cod-fishery. The advantages that may be secured by our bank-fishermen from the use of these nets can hardly be overestimated. It is altogether probable that they may be profitably employed on most of the larger fishing grounds, especially the Grand and Western Banks, and Banquereau. There is no good reason to doubt the practicability of underrunning nets on these banks, especially on the shoaler parts. They surely may be set and hauled on any part where cod are now taken. The use of these would obviate the necessity of leaving the bank before a trip had been secured, as must now be done by trawlers, in order to obtain a supply of bait. It is the general custom of the trawl-fishermen to use fresh bait, and since this will not keep longer than two to three weeks, it is easy to see that much time must be lost in seeking for it. Indeed, the supply is at all times so uncertain that some vessels are not actually engaged in fishing more than one-half of the time, and it may be safely said that bank-fishermen do not spend much more than two-thirds of their time on the fishing ground, the remainder being occupied in the search for bait. Again, a large sum of money is paid for bait, and, all things considered, it is quite apparent that even if the daily catch should be smaller than when trawls are used, the profits of the trip would be much greater.

As has been mentioned, however, nets have been found to work much better than trawls at Ipswich Bay, both on account of the quantity and quality of the fish taken. Since these facts are established, there is no

reason to doubt that similar results may be obtained on the banks. The difficulties of the bait question will then be done away with, and we may therefore confidently anticipate a marked improvement in the American cod-fisheries as a result of this change in the methods of fishing, and an emancipation of our bank-fishermen from their present dependence upon Canada for supplies of bait and ice.

D.—EXPLANATION OF THE PLATES.

PLATE I.—Method of hanging cod gill-nets in Norway.

1. Hanging rope or line.
2. Hanging twine.
3. Clove-hitch around the rope.
4. Upper part of the net meshes.
5. Open knot, showing how it is made.

PLATE II.—Manner in which the glass floats are attached to the top of the nets.

1. Glass float.
2. Eye of the float-covering.
3. Small rope holding the float to the net.
4. Eye-splice in rope C, and way in which it is fastened to the net.

PLATE III.—Way in which the sinkers are fastened to the bottom of the nets.

1. Sinker-stone.
2. Double line holding the sinker.
3. Foot of the net.

PLATE IV.—Size of twine of which the American nets are made.

PLATE V.—Norwegian method of setting the nets at the bottom.

1. Nets.
2. Large rocks used for moorings.
3. Buoy.
4. Buoy-line.
5. Glass floats attached to buoy-line.
6. Watch-floats.

PLATE VI.—Way in which nets are set at different depths to ascertain the position of the fish.

1. Nets.
2. Foot-lines by which the nets are held to the bottom.
3. Stone moorings to the nets.
4. Buoy-line.
5. Buoy.

PLATE VII.—Manner in which the ends of a gang of nets are attached to the stone anchors and buoy-line in Norway; also showing the position of the glass floats and sinkers.

1. Net.
2. Glass floats.
3. Sinkers.
4. Large stone anchor or mooring.
5. Anchor-line, called foot-line by the Norwegian fishermen.
6. Short rope, one end of which is bent to the lower corner of the net and the other in an eye of the buoy-line.
7. Short rope, one end having an eye-splice in it through which the buoy-line passes, and the other end bent to the upper corner of the net.
8. Buoy-line. The dotted lines show the probable position of the end of the net, buoy-line, &c., when swept back by the current.

PLATE I.

PLATE II.

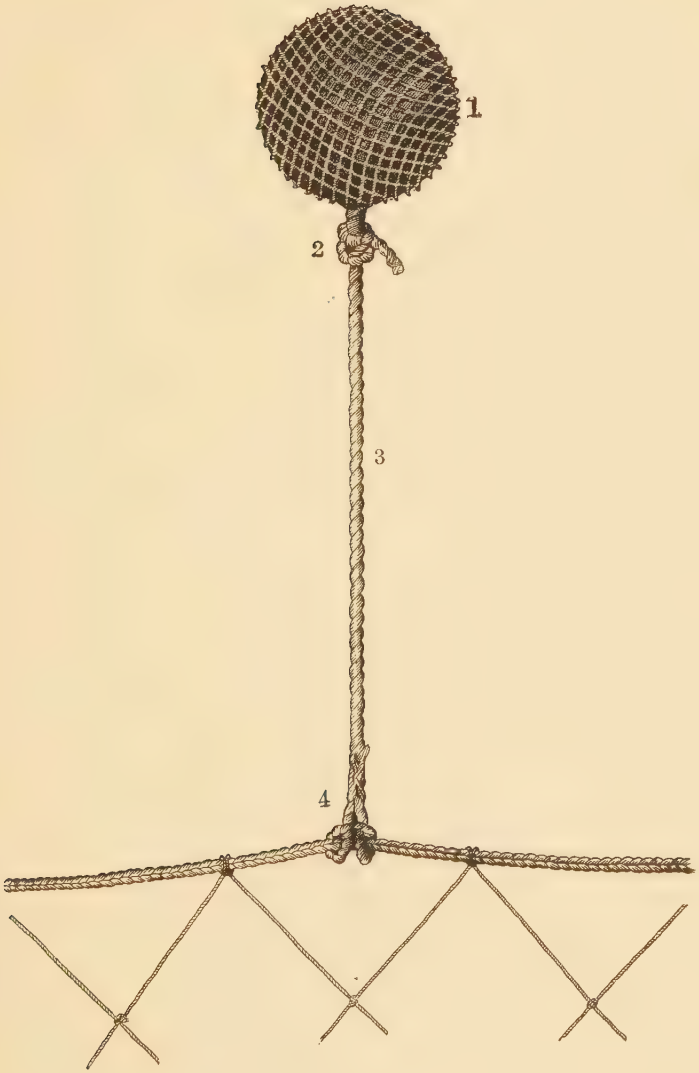
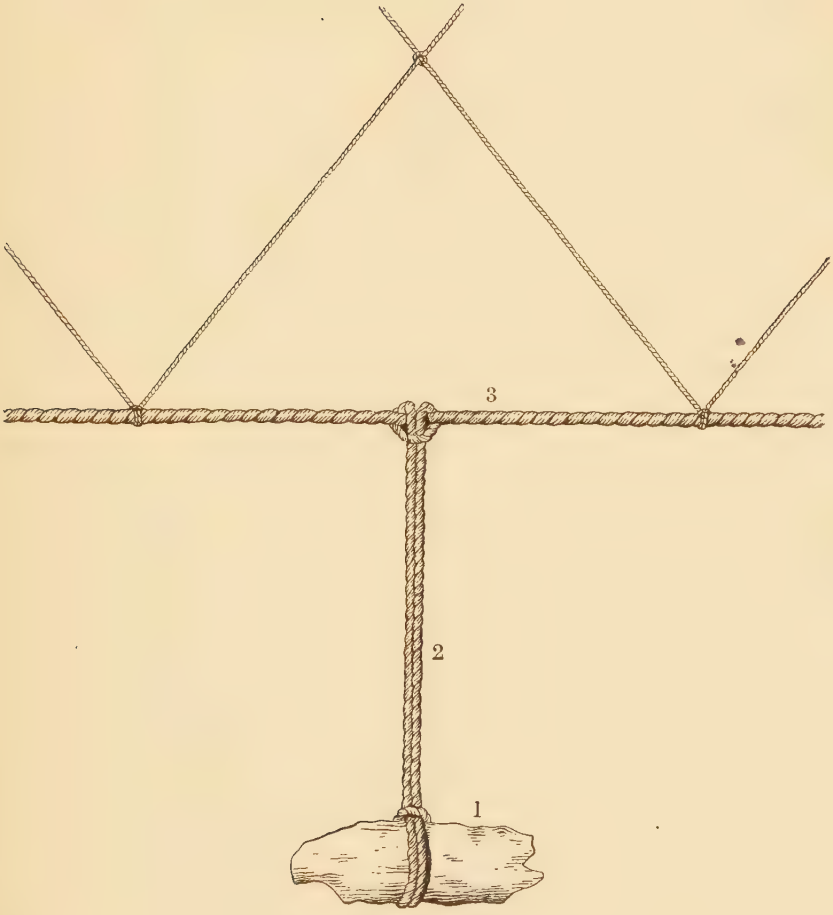
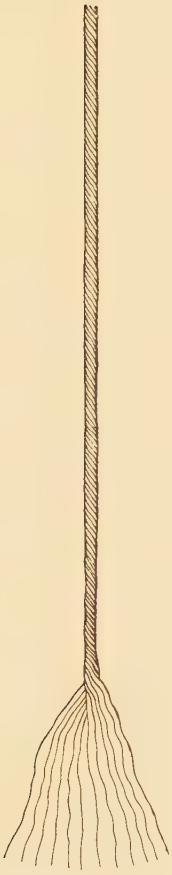


PLATE III.





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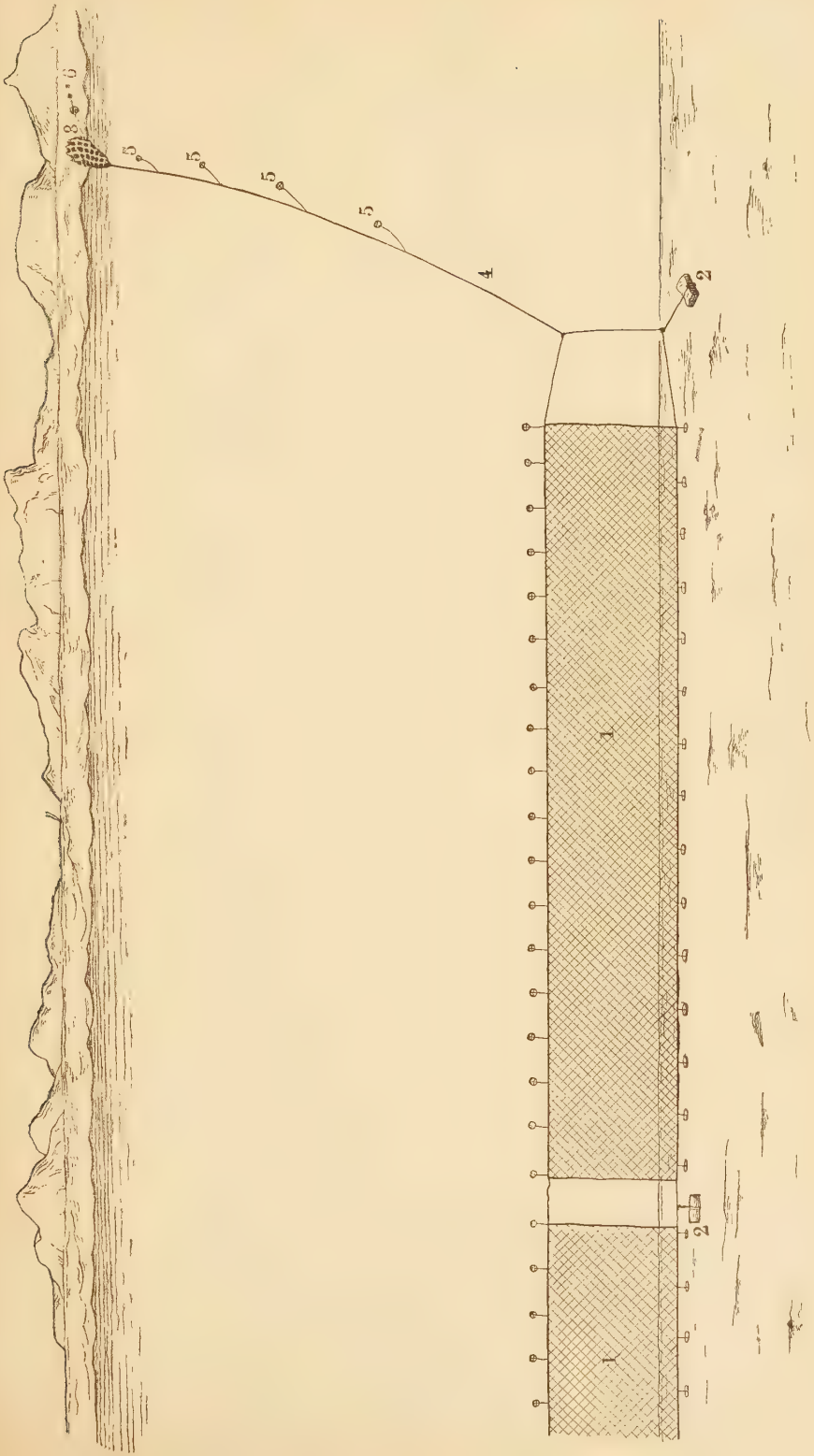

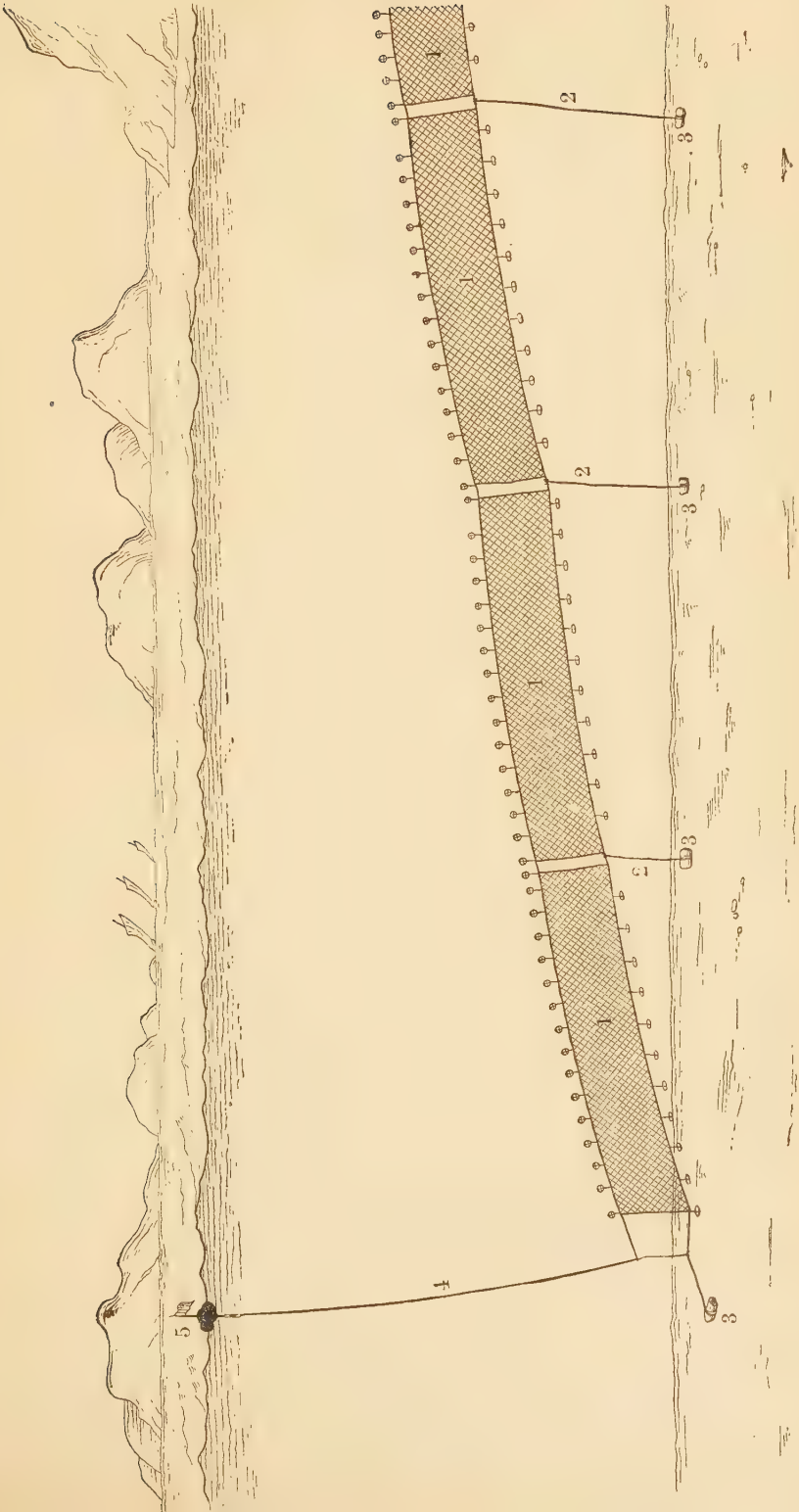
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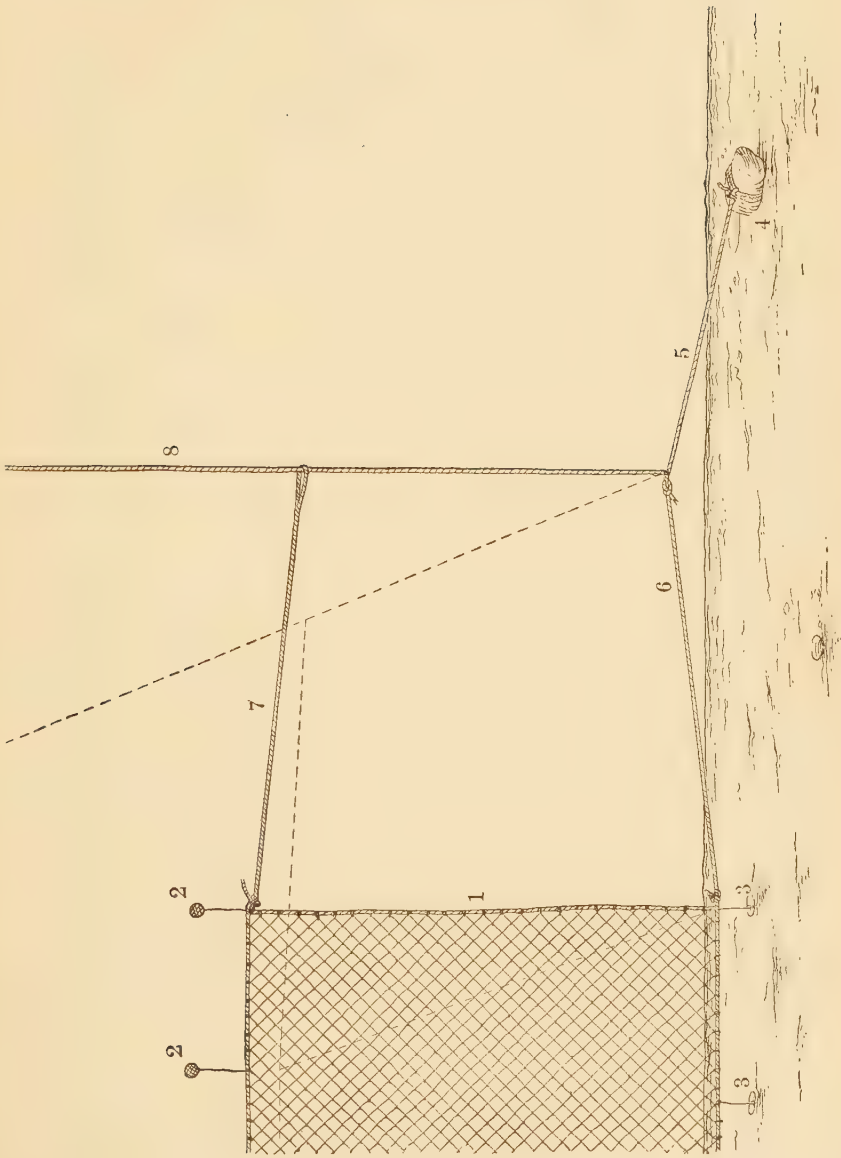
PLATE VII.



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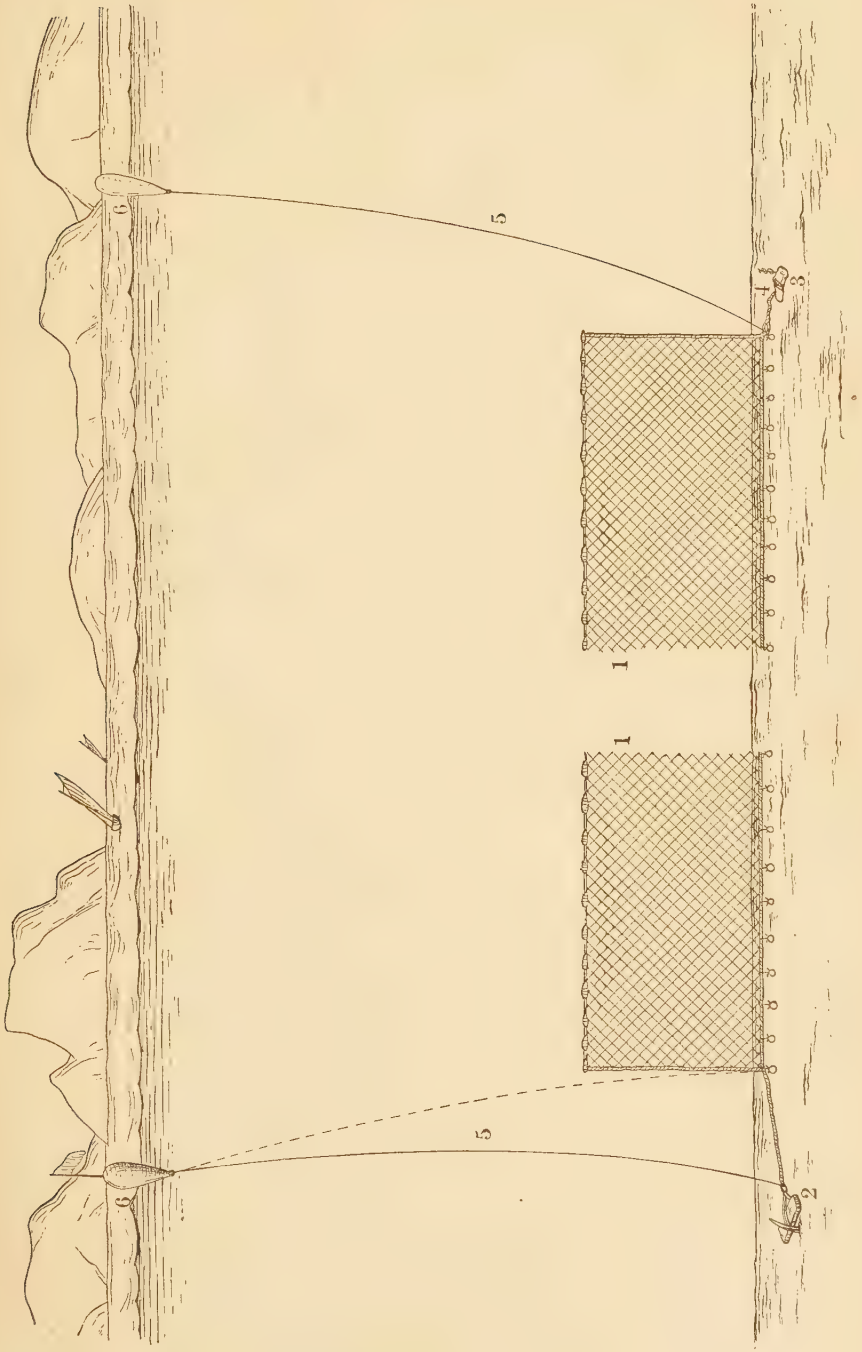
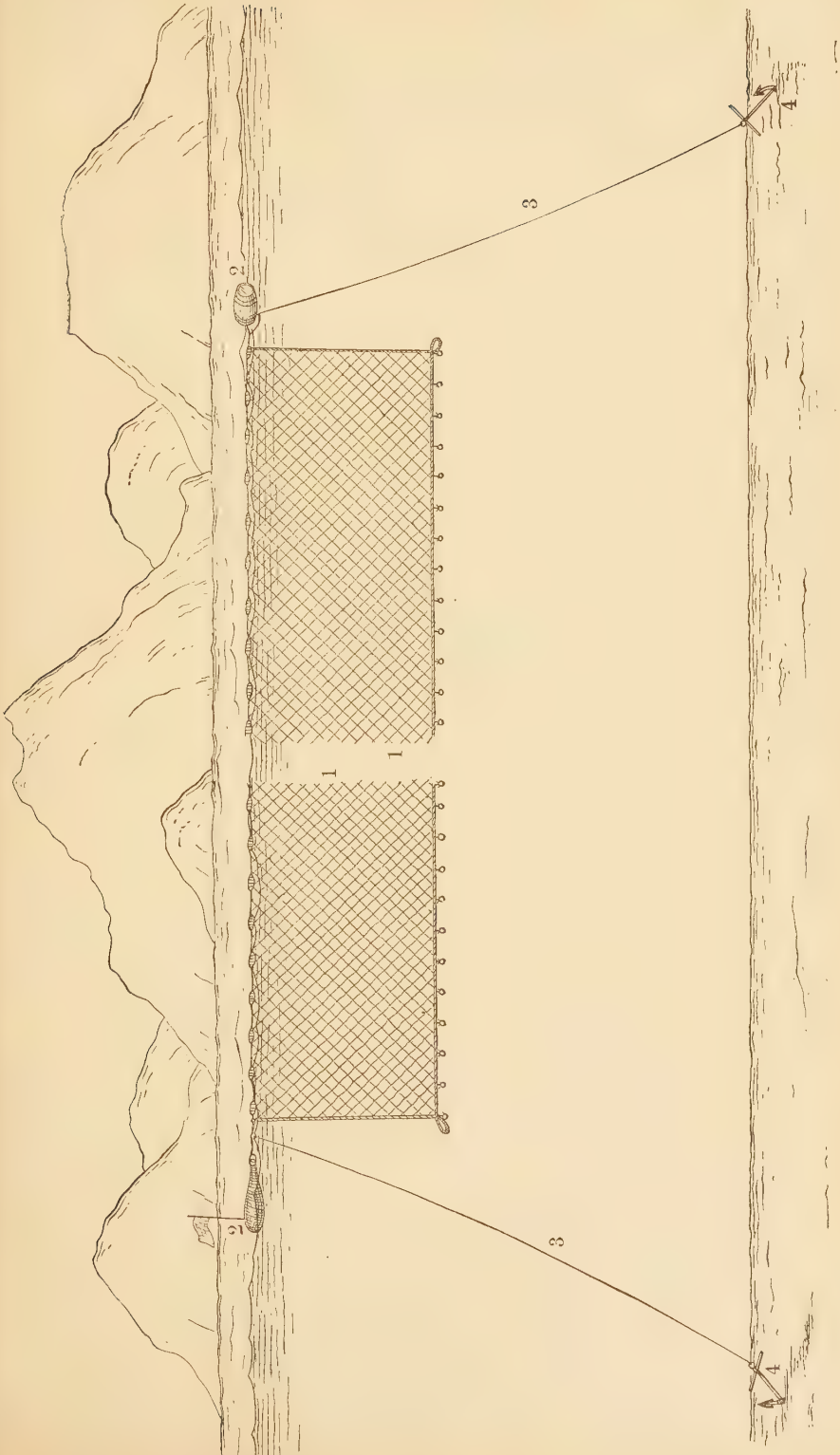


PLATE IX.



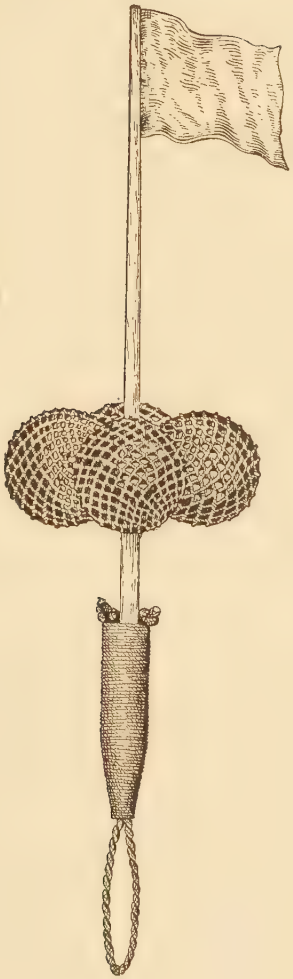


PLATE XI.

PLATE XII.

PLATE VIII.—Way in which cod gill-nets are set at the bottom on the east coast of Newfoundland.

1. Ends of the net or gang.
2. Stone killick, generally on the head end of the gang.
3. Stone mooring.
4. Anchor-line, one end of which is bent to lower corner of the net, and the other to the killick or stone mooring.
5. Buoy-lines. These are sometimes bent to the killicks, and at other times to the lower corner of the net, as shown by the dotted line.
6. Buoys.

PLATE IX.—The ordinary way in which cod gill-nets are set floating at Newfoundland.

1. Ends of the net or gang.
2. Buoys.
3. Anchor-lines.
4. Anchors. (Iron anchors, stones, or stone killicks may be used.)

PLATE X.—Norwegian net and trawl buoy made of glass floats.

PLATE XI.—Way in which cod gill-nets are set for underrunning in Ipswich Bay.

1. End of the gang of nets.
2. Anchor-line, also called the "underrunning line."
3. Anchor.
4. Buoy-line.
5. Buoy.

PLATE XII.—Manner in which the nets are underrun.

PROTECTION OF WHALES.*

[From a Christiania paper of January 25, 1881.]

As Norwegian laws cannot be enforced outside of Norwegian territory, the law of June 19, 1880, regulating the protection of whales on the coast of Finmarken, left it to the King to determine the limits of that portion of the sea to which protection should be applied. We have recently communicated a royal proclamation of January 5, 1881, giving the limits referred to. According to this the zone of protection extends one geographical mile from the coast, counted from the outermost islands which are never under water. In the Varangerfiord the outer limit of the zone of protection is a straight line from Kibergnas to Grause-Jacobselv; at Kibergnas, however, protection is to be enforced also outside that line at a distance less than one geographical mile from the coast.

The season of protection extends from the beginning of the year till the end of May. It is not easy to say beforehand what influence this limitation of the fishing season will have on the whale-fisheries, which are carried on in spring during the capelin-fisheries, and during summer. We do not possess sufficient data to show the result of the fisheries prior to the 1st of June and after that date. Svend Foyn has informed us that of 45 whales caught by him in 1876, 5 were caught during the period May 8—when fishing commenced—till the 1st of June; in 1877, 13 whales were caught prior to the 1st of June, and in 1878,

**Fredning af Hval.* Translated by HERMAN JACOBSON.

when altogether 97 were caught, 19 were caught prior to that date. The difference shown above is, therefore, brought about by the early or late commencement of the season and by the varying length of the capelin-fisheries; it should also be borne in mind that a number of whales are caught every year outside the zone of protection, where fishing is free all the year round.

The whale-fisheries have increased in importance of late years and form a considerable source of income to a number of our population. As far as we remember, Svend Foyn commenced operations in good earnest in 1868, and during the next eight or ten years he averaged 20 to 50 whales a year. After that period his fisheries increased rapidly; thus, in 1878 he caught 97 whales; in 1879, 83; and in 1880, 85. A joint-stock company, Jarfiord, in 1879 caught 45 whales, and in 1880, 60. These favorable results have stirred up a spirit of speculation, and recently there have been founded in and near Tönsberg no less than three new joint-stock companies for working the whale-fisheries, viz, the Stokke Company, which has bought a harbor at Pasvik, near Jarfiord, the Finmarken Company, which possesses a harbor in West Finmarken, on the south coast of the island of Sörö, and the Westfold Company, which has a harbor on the island of Magerö, near the North Cape. Each of these companies has a considerable capital and employs a steamer.

Whilst the protective law was being discussed, there was a great difference of opinion as to the advisability and necessity of limiting such important fisheries, already involving considerable interests; and the majority of the committee (of the Norwegian Parliament) who had the matter in charge were opposed to it. What finally decided the committee to declare in favor of a protective law was undoubtedly a regard to the very generally prevailing opinion that the whale-fisheries have exercised a hurtful influence on the cod-fisheries (capelin-fisheries). The cod follows the capelin, and the capelin, it is said, is chased towards the coast by the whale. It was maintained that the capelin would stay away if the whales were exterminated, and it was also said that the manner in which the whale-fisheries are carried on, the noise of the steamers, the shooting, &c., disturbed the capelin and chased them away from the coast, and that the filth inseparably connected with the preparing of the whale after it is caught would fill the sea-water and the coast with impurities and refuse, and thereby keep the capelin away. Science does not share this opinion, but maintains that the capelin seeks the coast in order to spawn, but that the whale only comes to seek food. It also is well to draw a comparison between the whales and the schools of herrings which periodically approach the southern coast of Norway. There is an old law prohibiting the catching of whales in a herring-fiord; but no spring-herring fisherman will at this day entertain the opinion that the whale chases the herrings towards the coast. Not even in the southern portion of Norway could any movement be set on

foot against the steamship traffic as a means of chasing the herrings from the coast.

Greater weight might possibly be attached to another reason advanced in favor of a protective law, viz, that an unlimited fishing season would diminish the number of whales and seriously endanger the future of the whale-fisheries. A reckless destruction of whales during the spawning season would certainly be a most senseless proceeding; and if we consider that last year no less than 145 whales were caught on a comparatively small extent of coast, such a fear is not entirely unfounded. Not long ago it has been found necessary to conclude an international convention between Norway, Sweden, Germany, Denmark, and England for the purpose of protecting the seal during its spawning season against the war of extermination waged against it near Iceland, Greenland, and Jan Mayen. It is to be hoped that it will be more generally recognized that we owe it to the coming generations to protect the useful and interesting animal life of the Arctic and Antarctic regions.

THE FOOD OF YOUNG WHITEFISH—COREGONUS CLUPEIFORMIS.

By Prof. S. A. FORBES.

DEAR SIR: The letter to Mr. Frank N. Clark which you kindly sent me last summer, resulted in an arrangement by which he was to hatch out a lot of whitefish eggs in January, and send me the young fry at intervals for a study of their food.

Having finished my study of these specimens, and thinking it probable that you would like to know the result, I will give you a brief outline of the observations made.

Mr. Clark writes me that these fry were divided into two lots, one (hatched January 18) being kept in a small tank in the hatchery, and the other (hatched January 20) in a perforated can in the stream from a spring. The water in the hatchery varied in temperature from 31½° to 48°, but was usually at about 37°; that of the spring was uniformly at 47°.

These lots were examined from the spring water February 1, 15, and 25. There were 242 individuals in these three lots. Only 8 of these gave any evidence of food in the intestine, and these in only trivial quantity. It included a few common forms of filamentous algæ, with smaller amounts of desmids and diatoms.

Samples of the water sent me contained an abundance of algæ, but no animal life except *protozoa* and *rotifera*. The remainder of this lot died late in February.

From the hatching-house four lots were sent, numbering 340 specimens, February 1, 15, and 25, and March 15. The last of these had reached a stage of development little, if any, in advance of that of the

first received from the spring. These fry were fed daily with *gammari* in minute fragments.

Of the first 90, 4 showed signs of food, 3 in the form of a few grains of dirt in the intestine, and the fourth a fragment of the crust of gammarus; in the second lot (111), 17 had eaten. I discovered 9 of these, and found only fragments of *Gammarus*. Twelve out of the 90 in the third lot had lately taken food; 4 had eaten fragments of *Gammarus;* 7, small particles of the leaves and stems of vascular plants; 2, larvæ of *Culicidæ* and 1, a *Cypris*, entire. In the fourth and last lot were 39 specimens; 14 had taken food, 5 in such minute quantity that I did not dissect them; *Gammarus* fragments were found in 4; larvæ of gnats (one *Chironomus*) in 3; and a minute vegetable fragment, a *Cyclops*, a *Cypris*, and some undetermined entomostracan each in 1.

To recapitulate: The specimens from the spring ate only vegetable food, but could apparently get nothing else. There was an abundance of vegetation about them, but only 3½ per cent. of them took food at all. They apparently died for want of animal food.

Fourteen per cent. of those from the hatching-house had taken food (47 out of 340). Of the 35 dissected, 18 had eaten fragments of *Gammarus;* 5, minute insect larvæ; 4, *Entomostraca;* and 8, small particles of vegetation. Few of these died, and those not used in the investigation were living a few days since.

A structural detail observed throws light on the question. With the complete disappearance of the egg-sac (and not before) two small, but stout, sharp, recurved teeth are developed on each side of the lower jaw. These are well adapted to the capture of a minute living prey, and apparently could not have any other use. I am very well satisfied, on the whole, that the earliest food of this fish will prove to be living *Entomostraca*, with probably some admixture of filamentous algæ. As the gill-rakers are not developed at this early age, I don't see how any smaller forms could be separated from the water, except accidentally.

The *Gammarus* "hash" makes evidently a very good substiute for the *Entomostraca*. The thicker crust and the necessary loss of much of the soft parts, in pulverizing the animals, make these less nourishing than the natural food—a fact likewise indicated by the greater abundance of the orange oil globules derived from *Crustacea*, in the intestines of those which had fed on *Entomostraca*.

I shall endeavor to collect some of the fry from Northern Lake, Michigan, next month, if I can get away, with a view to putting these conclusions to a more definite test.

Very respectfully, your obedient servant,

S. A. FORBES.

Professor S. F. BAIRD.

STATE LABORATORY OF NATURAL HISTORY,
NORMAL, ILLINOIS,
March 29, 1881.

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A VALUABLE EDIBLE MOLLUSK OF THE WEST COAST.

By JOHN A. RYDER.

The following extract from a list of shells sent with some specimens to Mr. George W. Tryon, jr., the Conservator of the Conchological Section of the Academy of Natural Sciences of Philadelphia, by Mr. Henry Hemphill, appears to me to be of importance as a contribution to economical science, and with Mr. Tryon's permission I am allowed to make use of it for publication.

"*Glycimeris generosa.* Olympia, Washington Territory.

"I send you a fine large specimen of this species. Its flesh is, I think, the most delicious of any bivalve I have ever eaten, not excepting the best oysters.

"When first dug and laid upon its back, it resembles a fat plump duck. The edges of the shell do not meet, but are separated by a breast of flesh [the greatly thickened mantle] about three inches wide, one inch thick, and about a foot long, including about half of its siphon. This portion is cut into thin slices, rolled in meal, and fried. It is exceedingly tender, juicy and sweet, and about the consistency of scrambled eggs, which it resembles very much in taste. The boys at Olympia call them "Geoducks"; they dig them on a certain sand bar at extreme low tide, and sell them to a merchant who ships them to Portland, Oreg., where they readily sell at fair prices. The boys inform me that the Indians on the Sound call them Quenux, and dry them for food with the other clams."

To give the reader some idea of the animal, let him suppose that he has before him a huge soft-shelled clam, with a very thick mantle, and a very stout siphon projecting from between the valves. From the habit of the animal it is clear that its propagation is effected in very much the same way as our own clam, and that the fry burrows into the sand and keeps the open end of the siphon projecting just above the surface.

The same methods of propagation would apply to both species. Artificial impregnation, which has been accomplished by the writer in the case of the clam, could no doubt be effected in this case. Then, with the proper incubator or hatching-box, provided with a bibulous membrane interposed before the outlet, the water could flow through and out, without losing the eggs; shallow pans of sand could also be provided at the bottom of the box for the young to bury themselves in, just as has already been proposed in the case of the clam. This is a subject which merits the attention of all interested in keeping up the productiveness and richness of our American shell fisheries.

PRELIMINARY NOTICE OF THE MORE IMPORTANT SCIENTIFIC RESULTS OBTAINED FROM A STUDY OF THE EMBRYOLOGY OF FISHES.

By J. A. RYDER.

At the last meeting of the Academy of Natural Sciences of Philadelphia (April 19), Mr. Ryder remarked that, as a result of his studies with the United States Fish Commission on the development of the bony or Teleostean fishes, he had learned that they differ in their mode of development from all other groups of vertebrates and fish-like animals, except the sturgeons, in having a cavity, the segmentation cavity, which persists and ultimately extends around the entire yelk as a paravitelline space between the epiblast and hypoblast layers of the embryo; this cavity in these fishes not being evanescent, as it appears to be in the embryos of the other sub-classes. The paravitelline space does not wholly disappear in the young fish until as much as two weeks after it leaves the egg. The segmentation cavity probably does not persist as long in fish embryos with a vitelline system of vessels as in the pike and stickleback for example.

An annulus or thickened ring of cells all round the edge of the blastoderm, continuous at one point with the tail of the embryo, limits the cavity alluded to above; the ring of cells the speaker called the periblastodermic annulus, and is characteristic of the embryos of true fishes and sturgeons. This feature characterizes these types, as far as is now known, as sharply from their relatives as does the anatomy of the adults.

The cleavage of the germ disk in bony fishes and sturgeons is regular, which further distinguishes them from other types, but they resemble the sharks in that the germ of the young fish is developed at the edge of the disk, and not in its center as in birds and reptiles.

A vesicle appears at the tail of the embryo when the blastoderm has covered rather more than half of the vitellus. This structure, which has been called Kupffer's vesicle, has not yet been proved to be an allantois, as was at first supposed, but is almost certainly a result of the invagination of the gastrula mouth or blastopore at the tail. The canal passing from it may be called Kupffer's canal, and opens on the dorsal face of the embryo. It may be continuous with the medullary canal.

The true nature of the gastrula was pointed out on homological grounds. The true gastrula of Teleosts appears to originate as an invagination at the tail of the embryo, represented by Kupffer's canal, essentially the same as in *Amphioxus*, and is not homologous with the gastrula regarded as such by Haeckel.

The paired fins originate from lateral folds, and the first skeletal elements of the breast fins in the cod are a pair of curved cartilaginous

arcs or rods which are not disposed radially, but concentrically to the base of the fin. These folds appear so far back on the embryo that their genetic relation to the gill arches appears improbable. The fin is displaced forwards with the growth of the young fish, and its base rotates through an angle of ninety degrees in acquiring the upright position.

PHILADELPHIA, *April* 20, 1881.

REARING OF CALIFORNIA MOUNTAIN TROUT (SALMO IRIDEUS).

By SETH GREEN.

(Extract from a letter to Prof. S. F. Baird, May 3, 1881.)

I have 220 six-year old California mountain trout, some of them weighing 3 pounds, and 10,000 three-year old that we are taking the spawn from now. One day last week we took 88,000 spawn. We shall have next year 30,000 more three years old. We have orders for all we shall take this year. But next year we shall have many millions. They are a hardy game fish. They spawn in the spring, and hatch in streams a much larger percentage than our trout. They will live in any streams that our trout will, and in many warmer streams that our trout will not live in. This is the fourth season that we have taken the spawn, and every year a good many have hatched in our spawning-races. We never saw one of our trout or salmon-trout hatched in the races. Seven years ago I got 300 of their eggs; we hatched and raised 275; when they were three years old we took 64,000 eggs and raised 10,000 for breeders. The next year we had 260 of the old stock, and took 90,000, and raised 30,000 for breeders and distributed the rest. Last year we had 220 of the old stock; we took 80,000 eggs and are raising 12,000.

SALMON CAUGHT IN GENESEE RIVER, NEW YORK.

By SETH GREEN.

NEW YORK STATE FISHERY COMMISSION,
OFFICE OF THE SUPERINTENDENT,
Rochester, N. Y., May 3, 1881.

* * *: Last week five salmon were caught in the Genesee River, weighing from 3 to 10 pounds. They were caught in small scoop-nets. The falls are seven miles from Lake Ontario. They are 87 feet in perpendicular height. Eighty rods above is another fall of 90 feet. Then the river, 90 miles to its head in the Allegheny Mountains, is a clear stream for 40 miles. Then it comes on large flats with clay banks, and becomes very roily during floods. The young salmon were put in the tributaries above the falls. They have gone over the falls and

come back to them again thinking they could get back to the streams to spawn where they spent their childhood days, but the leaps are too much for them. There never were any salmon caught in the Genesee before last year. I have fished the river for fifty years. I do not know whether they were California or Kennebec salmon; I did not see them. The fishermen think we do not want them caught, and have kept shy of me. I have spent some days on the river since to let them know that we did want them caught in the spring of the year, and to let me know if they catch any more.

NOTES ON THE DEVELOPMENT, SPINNING HABITS, AND STRUCTURE OF THE FOUR-SPINED STICKLEBACK, APELTES QUADRACUS.

BY JOHN A. RYDER.

Nests and ova of this species were recently brought to me for investigation by Mr. W. P. Seal, who obtained them in the ditches along the Delaware, below Philadelphia. More recently (April 27), the same gentleman had the kindness to bring me a pair of adults about to spawn, the male very industriously completing the nest under my observation in an aquarium extemporized for the purpose.

The early stages of development I did not witness, as the first lot of eggs had the blastoderm already formed, and inclosing the vitellus, and those laid by the pair in confinement were unluckily not impregnated. The egg-membrane is a true zona radiata, being perforated by numerous pore canals, and is covered by an adhesive material, which agglutinates the eggs together into a mass to the number of 15 to 20, the number laid at one time. The ova sink to the bottom, and must be taken charge of by the male, as the female after having ridden herself of them takes no farther interest in their welfare. They measure one-twelfth of an inch in diameter, and are of an amber color. I was not able to discover a micropyle, but believe that one exists, nevertheless; at one pole of the egg a large number of button-shaped appendages are attached to the surface of the egg-membrane by means of pedicels, and it is in the midst of these that the micropyle is found in the European species, *Gasterosteus leiurus*, according to Ransom.

Not having witnessed the early stages of development, I will only describe the structure of the ovum. There is no germinal disk developed when the egg first leaves the ovary, and the germinal layer is uniformly distributed as a thin uniform granular envelope, inclosing the clearer vitelline protoplasm, which itself incloses a number of very refringent oil spheres of very variable size. Later, it appears that a germinal disk is developed without the influence of impregnation.

The formation of the segmentation cavity I have not witnessed, but I have a belief that it is present, inasmuch as there is a space developed

on either side of the embryo and in front of the head, which answers to it. It is, however, greatly obscured afterwards, if not obliterated at a comparatively early period, by the remarkable way in which the blood vascular system of the embryo is formed.

On the fourth or fifth day after impregnation, the primary divisions of the brain are marked off, one of the most striking characters being the extraordinary dimensions of the cerebral vesicles, the walls of the brain cavity being thinner proportionately than I have ever found them in other forms. The optic cups also differ in their structure from those found in other fishes, in that there is a great space between the floor of the cup and the lens, the origin of which from an induplication of the epiblast may be very readily traced. Immediately behind the auditory vesicles, and shortly after their invagination, the rudiments of the breast fins appear as a pair of longitudinal folds. These therefore originate closer to the branchial arches than those of any other species studied by me. As they often are found to originate on either side of the embryo above the posterior end of the yelk-sack, and near a vertical from the point where the vent appears. This latter is their mode of development in the cases of the young of the moon-fish (*Parephippus*) and the Spanish mackerel (*Cybium maculatum*). In the stickleback, however, there is an extraordinary acceleration in the development of the breast fin, so much so that by the time the young fish leaves the egg, the breast fins are as greatly developed as in a mackerel four days old. The pigmentation of the young stickleback is also accomplished at a very early period, so rapidly, indeed, that it soon becomes impossible to see the viscera through the mantle of pigment cells. There is another complication which needs mentioning here, and that is the fact that a second kind of brown pigment cell, much larger than the black ones appears on the skin before the young slips out of the egg. These brown cells blotch the embryo on the sides and back somewhat symmetrically, and foreshadow the style of pigmentation of the adult.

The heart appears about the fourth day as a heap of mesoblast cells just below and behind the head, and is at first a simple spherical sinus. It does not begin to contract vigorously until the seventh day, when its pulsations are nearly if not quite 100 per minute. Its venous end rapidly elongates until it extends fully the diameter of the body beyond the right side of the embryo, a large pericardial space being developed below the head at this point for its lodgment, which space dips down deep into the amber-colored vitellus. It keeps contracting from this time onwards, but there are as yet no blood corpuscles. A large space now appears on the right side of the embryo and underneath the latter. This we may consider a venous sinus or channel of indefinite outline. The floor of this space is, as far as I have been able to convince myself, formed of the hypoblast from which knobbed cells project upwards, which appear to be budding off portions of themselves which will become blood corpuscles. Now follow amœboid contractions of the yelk

by means of which it appears that this sinus is pushed out more to the right and subdivided into minor channels, the corpuscular contents of which flow towards the heart, pouring their contents into its venous end. At first it can scarcely be said that there is a circulation; the corpuscles appear and the pulsation or pumping action of the heart causes an oscillation or swaying back and forth of these corpuscles. As soon as the aortic channel underneath the chorda dorsalis is broken through the blood commences to pour through the sinus from the tail end headwards, as the cycle is now complete. The cardinal vein is formed about the same time. From it the feeders of the sinus, now the vitelline vessels, are soon developed and they now spread out over the yelk as narrow channels, becoming more and more numerous. They at first spread out over the aboral pole of the yelk, and a great common venous channel begins on the left side of the embryo and goes round to the right side over the yelk like a girdle, to feed the heart. Into this equatorial vascular girdle the blood pours from the hemi-meridional, aboral channels. This asymmetrical or right-hand side channel is gradually pushed forward until it encircles the head below and in front of the point where the mouth will appear. The yelk is now becoming less in bulk, and finally the vessels arrange themselves so that the main venous channel lies in the middle line, while the feeders which get their supply from under the body of the embryo trend outwards and somewhat backwards, but as they turn to traverse the lower face of the yelk they one and all trend forward to converge and join the great venous channel.

The above arrangement may be described as a diffuse omphalomeseraic system, and differs from that of *Zoarces* described by Rathke, in being asymmetrical, and from that of the pike as described by Truman, in the disposition of the vessels, their more meridional course, and in their being fed from the under side of the body in a diffuse manner. It differs widely from that of birds and reptiles and sharks in there not being any differentiation of venous and arterial trunks over the blastoderm. Also from the system described by Vogt in *Coregonus palæa*, in that the latter is comparatively rudimentary, while as compared with the cod, smelt, moon-fish, and Spanish mackerel, there is the broadest and most fundamental difference of all, in that in every one of the latter there is nothing whatever which can be considered as representing an omphalomeseraic or vitelline system of vessels.

Gensch* has lately studied the development of the blood in *Zoarces* and *Esox* by means of sections, and has reached the conclusion that the blood corpuscles in these forms are developed by budding off from the hypoblast as it has appeared to me in the case of the stickleback. This announcement at first appeared almost incredible to the writer, but upon investigating the form above described it appeared perfectly reasonable, but it must be borne in mind that there are no less than four or five dis-

*Die Blutbildung auf dem Dottersack bei Knochenfischen. Arch. für Mik. Anat., xix, pp. 144–136.

tinct hypotheses as to the origin of the blood in embryos, besides this one, so that the matter cannot be considered as settled. In all cases where there was no vitelline circulation I have not been able to arrive at a satisfactory conclusion in regard to the manner in which the matter in the yelk-sack was absorbed; whether by transudation, amœboid migration, or gemmation, and it therefore still remains an unsettled problem. It will not, it appears to me, satisfy the facts in the case, that because the blood originates by gemmation from the hypoblast in those cases where there is a vitelline circulation, it should so originate where such a circulation is absent. The corpuscles of the stickleback are at first irregular and amœboid in outline, and do not acquire their oval shape for some time, or till about the tenth or twelfth day, when the young fish is ready to leave the egg, which is strong evidence in confirmation of Gensch's view as to the manner of origin of the blood of types with a vitelline or omphalomeseraic circulation. In other forms it has always appeared to me that there was strong ground for believing that the blood had its origin, in part at least, in the lacunæ which make their appearance in the mesoblast of the body late in embryonic life.

The heart retains its horizontal position in the stickleback for a longer time than in any other form which I have studied, and is an instance of what Professor Cope would call retardation in the development of a part; indeed, the comparative histories of the several species investigated by the writer afford most beautiful illustrations of both principles enunciated by the learned biologist just referred to, namely, *acceleration and retardation* of development, both synchronous and heterochronous. This long retention of an embryonic character is, however, to be considered as caused to some extent by the development of an omphalomeseraic system, and as in some degree dependent upon the correlative interdependence of parts serving a common purpose.

Kupffer's vesicle was found to be present, and at one time I believed that it became the allantoid vesicle, but owing to the opacity of the eggs I failed to trace it satisfactorily to myself. The allantoid, however, occupies the usual position, and is large and inclosed by a proper cellular wall. The course of the intestine when the embryo is nearly ready to hatch is marked by a greenish color. The blood very soon becomes reddish in color before the fish leaves the egg, a character which it has in common with no other form studied by me, except perhaps the sculpin. In all other cases investigated by me, the blood is developed after the embryos leave the egg. There is also a well-developed system of vascular loops existing in the natatory folds along the back and belly before the fish is ready to leave the egg, while the branchial vessels, arches, and opercula are already in an advanced condition at this period, all of which are accelerated conditions of development as compared with other forms.

When the embryo leaves the egg there are already lateral sensory organs developed on the skin. If the young fish is allowed to assume its normal position in a cell, and the microscope is applied, looking down

past the sides of the body from above, certain thickenings of the epiblast or skin layer will be noticed. These thickenings are surmounted by transparent cells which project freely for a little distance from the general level of the surface. The cells to the number of ten or twelve are somewhat separated from each other, and have blunt truncated tips which are not surmounted with sensory hairs or filaments. As compared with the similar structures in the young cod, which have sensory hairs surmounting them, they differ in having the peculiar, somewhat separated truncated transparent cells clothing their surface externally, while in the former nothing is seen from above but a smooth rounded elevation.

Spinning habits and structure of the male.—The male binds the nest together by means of a compound thread which he spins from a pore or pores behind the vent, while he uses his bobbin-shaped body to insinuate himself through the interstices through which he carries his thread with which he binds a few stalks of *Anacharis* or other water-weeds together, bringing in his mouth every now and then a contribution of some sort in the shape of a bit of a dead plant or other object, which he binds into the little cradle in which the young are to be hatched. The thread is spun fitfully, not continuously. He will go round and round the nest for perhaps a dozen times, when he will rest awhile and begin again, or turn suddenly round and force his snout into its top with a vigorous, plunging motion as if to get it into the proper shape. Its shape is somewhat conical before completion, an opening remaining at the top through which it is supposed he introduces the eggs. The thread is wound round and round the nest in a horizontal direction in the case we are describing, and if this thread is placed under the microscope when freshly spun, it is found to be composed of very thin transparent fibers to the number of six or eight; where they are broken off they have attenuated tapering ends as though the material of which they were made had been exhausted when the spinning ceased. Very soon after the thread is spun particles of dirt adhere to it and render it difficult to interpret its character. I have seen the thread being drawn out from the abdomen repeatedly, but not from the vent; it appeared to me more probable that it came from the openings of a special spinning gland. Its glass-like transparency shows that it is not made up of ingested food, the particles which would exhibit themselves were that the case. The nest measures half an inch in height and three-eighths in diameter.

Upon opening the male I find a large vesicle filled with a clear secretion which coagulates into threads upon contact with water. This vesicle appears to open directly in front of the vent, separately from the latter. It measures one-fifth inch in length and an eighth in diameter. As soon as it is ruptured it loses its transparency, and whatever secretion escapes becomes whitish after being in contact with water for a short time. This has the same tough, elastic qualities as when spun by the animal itself, and is also composed of numerous fibers, as when a portion is taken

which has been recently spun upon the nest. The nature of the opening was not learned with precision as I possessed only a single specimen. The vesicle lies to the right side of the intestine, and there is very little doubt but that it opens in front of the anus. The testes are two ovoid glands, the ducts of which unite into a common canal, both glands and ducts being covered with black pigment cells; they measure something less than an eighth of an inch. As to the origin of the secretion I have no suggestion to make, but there are certain glandular structures lying close by, the significance of which I was at a loss to understand.

This spinning habit of *Apeltes* was first noticed by my friend Mr. Seal, who has watched the breeding and nursing habits of these interesting fishes very closely, and it is my hope that I may some time be able to deal more at length with this part of the subject with the help of his notes and beautiful sketches.

PHILADELPHIA, *April* 29, 1881.

A CALL FOR CARP FROM NEVADA.

BY I. D. PASCO.

This country is the most God-forsaken country in the world—a mining camp (silver), and the water small streams from the mountains. The nearest fish are in the Reese River, 30 miles distant. Reese River would not be called a creek in Pennsylvania; it would be a brook. When I tell you that last winter trout came from Truckee and Walker Rivers embalmed in snow and ice, and sold for 37½ cents per pound, you will see that we have reason to be anxious about the matter. The big thing is to get a good start (to get the fish), get them to breeding and we will supply and stock the country. I would give $5 for a pair that are big enough to spawn now. Our waters teem with insect life but not a fish, and I know that fish would live in them although our springs are all warm, and some boiling hot. The water in the streams from the mountain, consisting of snow water, sinks sooner or later. I have as a place to begin with a pond—an old channel of this stream (Meadow Creek) 16 feet wide, 40 rods long, and 2 feet deep, of pure water. I will give you a description of a place Mrs. Hathaway, a widow, owns: There are as many as twenty springs rising in a half circle and running a stream about 3 miles, a good step across the stream; there are fish that never get longer than 3 inches, too small for use. How they ever got there is unknown, for the water does not connect with any place. Here a 3-foot dam, 50 yards long, would cover 50 acres. Give us the fish, and we will build reservoirs to hold the snow water, and use for irrigation and fish ponds. The two will work well together. I cultivate the water cress for sale in Belmont; it does well, but the *algæ* (frog spittle) is a great bother in the cress beds. Here are two articles that the carp would eat; and I believe in the warm springs they would not in the winter be dormant in the mud, but grow all winter.

I am the first man that broached the fish business, but rest assured that all having streams want them. Once fairly established in the country we will sell to one another, because any person will be able to pay a higher price for breeding than for eating. If necessary we will meet the thing with cash, according to our wants and means.

Now, if possible, do not neglect us. We are all Uncle Sam's boys, and will appreciate the fish beyond any other section, and for the very reason that they will be a luxury for our own tables and nothing will sell better. It cannot be over done. Our greatest obstacle would lie in the Indians; a mean, stupid pack, that only think of stealing as a virtue; but once fairly started we can manage them.

The best route would be the Pacific Railroad to Battle Mountain, then a narrow gauge to Austin, and from Austin to Belmont 68 miles. You will find applicants at Austin, and on the road from Austin to Belmont. If you can send spawn by express or mail, it would be the best way. We have a stage three times a week from Austin.

Last season I persuaded the man above me on my stream not to go to Reese River after trout, because I hoped sooner or later to get carp, and I did not want trout in the stream to eat the young. I repeat, stock us at once if possible. Rest assured we will meet you with all assistance in our power, and appreciate your efforts beyond any other section. I have had worms an inch and a half long in my irrigating ditch, and could gather them by the handful.

Yours truly,

I. D. PASCO,
Belmont, Nye County, Nevada.

THE CARANGOID FISHES OF THE UNITED STATES—POMPANOES, CREVALLÉS, AMBER-FISH, Etc.

By G. BROWN GOODE.

The members of the family *Carangidæ* are distinguished chiefly from the mackerels, to which they are closely allied, by the absence of finlets and by the fact that they have uniformly but 24 vertebræ, 10 abdominal and 14 caudal, while the mackerels have uniformly more, both abdominal and caudal. They are carnivorous fishes, abounding everywhere in temperate and tropical seas. On our own eastern coast there are at least 25 species, all of them eatable but none except the Pompanoes of much importance; on the California coast there are two or three species of this family of small commercial importance.

The Blunt-nosed Shiner.

(*Argyriosus setipinnis.*)

This fish, known on some parts of the coast as the "Horse-fish," in North Carolina as the "Moon-fish" or "Sun-fish," and in Cuba by the

name "Jorobado," was called by Dekay "Blunt-nosed Shiner," and since this name, sometimes varied to "Pug-nosed Shiner," is in common use in New York market and in Narragansett Bay, while the other names are shared by other species similar and dissimilar, it seems the most suitable for general adoption. The fish is found everywhere throughout the West Indies as well as in Northern Brazil and in the Gulf of Guinea, but has not been found in Europe, nor, as yet, has it been recorded from the Gulf of Mexico. In Eastern Florida it is not very unusual, being frequently taken in the lower Saint John's and sometimes driven up as far as Jacksonville by easterly storms. Here and in the Indian River it is known as the "Moon-fish." It is a frequent summer visitor all along the coast as far north as Wood's Holl, Massachusetts, where it has a peculiar name, the people there calling it the "Hump-backed Butter-fish." The species attains the length of 10 or 12 inches and is esteemed an excellent article of food. Considerable numbers are brought yearly to New York, but elsewhere it rarely appears in the markets. Young, from 3 inches in length upwards, are found, but we have no definite knowledge as to its breeding habits.

The Silver Moon-fish.

(*Selene argentea.*)

The Silver Moon-fish, which much resembles the one just described, is often spoken of under the same names, and is not likely to be distinguished from it by casual observers. On the Carolina coast, according to Mr. Earll, it bears the expressive name of "Look-down." It occurs sparingly on our coast as far north as Wood's Holl, and is found in the West Indies, in Brazil, and in the Gulf of Mexico. Its body is thinner, and it is consequently less desirable for food.

The Dollar-fish.

(*Argyriosus vomer.*)

This species, which has by many authors been considered to be the young of the Silver Moon-fish, is a small fish quite abundant in our waters, frequently taken in Massachusetts Bay, and, in one or two instances, as far north as Halifax, Nova Scotia. Its range coincides closely with that of the species last mentioned. Its body is so thin that it can be dried in the sun without the use of any preservatives, retaining its shape and color. It is consequently of no importance as a food-fish.

The Round Robins.

(*Decapterus punctatus and D. macarellus.*)

The Round Robin, *Decapterus punctatus*, or, as it is called at Pensacola, the "Cigar-fish," occurs in the Bermudas, where it is an important food-

fish; it is found also in the West Indies and along the coast of the United States north as far as Wood's Holl.

A closely related species, *Decapterus macarellus*, is found also in the West Indies and along the eastern coast of the United States. According to Stearns, individuals of this species are rather rare in the northern part of the Gulf, but more common along the South Florida coast. They live in shallow water and in harbors, usually moving about in small schools. At Key West they are caught in seines and are eaten.

The Jurel.

(*Paratractus pisquetus.*)

This fish, known about Pensacola as the "Jurel," "Cojinua," and "Hard-tail," along the Florida coast as "Jack-fish" and "Skipjack," in the Bermudas as the "Jack" or "Buffalo Jack," in South Carolina as the "Horse Crevallè," at Fort Macon as the "Horse Mackerel," about New York and on the coast of New Jersey as the "Yellow Mackerel," is found in the Western Atlantic from Brazil, Cuba, and Hayti, to Halifax, Nova Scotia, where specimens were secured by the United States Fish Commission in 1877. It is one of the commonest summer visitants of the West India fauna along the whole coast of Southern New England and the Middle States, and is especially abundant in the Gulf of Mexico, and is one of the commonest fishes in the Bermudas. This fish is occasionally brought to the New York market; but is of no special importance as an article of food north of the Gulf of Mexico. Concerning its habits in those waters, Mr. Stearns has contributed a very interesting series of notes. His observations are especially instructive since nothing has previously been known of its life history.

"It is extensively abundant everywhere on the Gulf coast of Florida, Alabama, and Mississippi. At Pensacola it is one of the important fishes of trade and is highly prized for food. It is one of the class of migratory fishes of this coast, like the Pampano, Mullet, Spanish Mackerel, and Redfish, having certain seasons for appearing and disappearing on the coast and also has habits during these seasons that are peculiar to themselves or their class. It appears on the coast in April in small schools that swim in shoal water near the beach during pleasant weather, when there is little or no surf, in 8 or 10 feet of water, and in stormy weather some little distance from the breakers. Their movement is from the eastward to the westward. As they seldom swim at the surface their movements can be watched only when in shoal water. The schools 'running' in April and first of May are usually smaller than those of a few weeks later; but the individuals of the first are somewhat larger. The mass or largest 'run' comes in May, and it is on the arrival of these that schools are first seen coming in the inlets.

"A noticeable peculiarity of the Hard-tail compared with some other common migratory fishes, is that the first schools do not stay about the

mouths of an inlet and along the beach weeks before coming inside as those of the latter do, but continue their westward movement without seeming to stop to feed or play until the time has come for a general movement towards the bays. In this way they must be distributed along the coast with no unequal accumulation at any one point. When once inside, the numerous schools break up into smaller ones of a dozen or two fish, which are found in all parts of the bay during the summer. On their arrival the larger fish contain spawn, which in July and August becomes quite full, after which none are seen but the young fish of about 10 inches in length, until there is a general movement towards the sea. It is believed that the adult fish spawn in the bays, but the only evidence to support that belief is that they come inside with spawn, go away without it, and that very young fish are found there. In October and November small Hard-tails are caught in Santa Rosa Sound measuring 5 and 6 inches in length.

"The smallest of the spring run are 9 or 10 inches long. Adult fish measure 12, 14, and 15 inches in length, very rarely more than the last. During the months of October and November Hard-tails leave the bays formed in small schools, and swimming below the surface in deep water. The only time that they can then be seen is when they cross the 'bars' at the inlet or sandy shoals in the bay. A few stragglers remain in Pensacola Bay and Santa Rosa Sound all winter, which are taken now and then with hook and line. I have found them in abundance in winter on the South Florida coast, where, owing to less variable conditions of the water, their habits are decidedly different. The Hard-tail is a most voracious fish, waging active war upon the schools of small fish. Its movements are rapid, and sometimes in its eagerness it will jump high out of the water. It has its enemies also, for I have seen whole schools driven ashore by sharks and porpoises; a great many are destroyed in this way. Hard-tails are caught for the market in seines."

The Goggler.

(*Carangus crumenopthalmus.*)

This fish, called in the Bermudas, where it is of some importance as a food-fish, the "Goggler," or "Goggle-eyed Jack," and in Cuba the "Cicharra," occurs in the West Indies and along the Atlantic coast of the United States north to the Vineyard Sound. It is also found at Mauritius, and in the Pacific, Atlantic, and Indian Oceans, the Red Sea, and off the coast of Guinea, while, as has been remarked, it is abundant in the Bermudas. Its large, protruding eyes are very noticeable features, and the Bermuda name seems appropriate for adoption, since the fish has with us never received a distinctive name. In form it somewhat resembles the species last discussed, with which, also, it is probably often confused.

Stearns speaks of a fish, common at Key West, which is known as the "Horse-eyed Jack," and this may prove to be the same species.

The Cavally.

(*Carangus hippos.*)

The Cavally of the Gulf of Mexico and Eastern Florida—the Horse-crevallè of South Carolina—occurs abundantly on our southern coast, and has been recorded by Professor Poey from Cuba, and by Cope from St. Christopher and St. Croix. It has been so confused with other species of the same genus that at present it is impossible to state its distribution throughout the West Indies. The species was originally described from specimens sent from South Carolina by Garden to Linnaeus. The name of this fish is usually written and printed "Crevallè," but the form in common use among the fishermen of the South, Cavally, is much nearer to the original Spanish name, Cavalha, or Cayalla, meaning "horse." The name as used in South Carolina is a curious reduplication, being a combination of the English and Spanish names for "horse." It should be carefully remembered that in South Carolina the name Crevallè is most generally applied to quite another fish, the Pompano.

The Cavally, as it seems most appropriate to call *Carangus hippos*, though in individual cases occurring as far north as Cape Cod, and even, in one instance, at Lynn, Mass., is not commonly known in the United States north of Florida. Storer remarks: "This fish is so seldom seen in the waters of South Carolina that we are unacquainted with its habits."

I observed a specimen in the Jacksonville market in April, 1874. Concerning the Cavally of Southern Florida, which is either this or a closely allied species, Mr. H. S. Williams remarks:

"In the Indian River this is one of the best of the larger varieties. Its season is from the 1st of May to November. It ranges in weight from three to twenty pounds, being larger and more numerous to the southward toward the Mosquito Inlet. The south end of Merritt's Island and the inlets opposite old Fort Capron seem to be a sort of headquarters for the Cavalli. When in pursuit of prey they are very ravenous, and move with the rapidity of lightning. They readily take a troll either with bait or rag. The favorite mode of capturing them, as well as all other large fish that feed in shallow water or near the shore, is with a rifle. The high rocky shores afford an excellent opportunity for this sport, though the rapid movements of the fish render them very difficult targets."

Mr. Stearns writes: "The Crevallè is common on the Gulf coast. In West Florida it appears in May and remains until late in the fall. Is equally abundant in the bays and at sea. In the bays it is noticeable from the manner in which it preys upon fish smaller than itself, the Gulf Menhaden and Mullet being the most common victims. On arrival it contains spawn, which it probably deposits in the salt-water bayous, for in the fall schools of young are seen coming out of those places on their

way to the sea. These young are then of about one pound weight, appearing to the casual observer like Pampano, and I am told that they equal it for edible purposes. They are caught accidentally by seines and trolling-lines. Large ones are not considered choice food, the flesh being dark and almost tasteless. The average weight is twelve pounds; occasionally they attain the size of twenty pounds."

The Golden Mackerel.

(*Carangus chrysos.*)

The Golden Mackerel, called "Yellow Mackerel" at New York, and "Sun-fish," in North Carolina, is said to be somewhat abundant in Beaufort Harbor. It has also been obtained at Wood's Holl, Mass. It has been confused with the other related forms and but little is known of it. The species called by Girard *Carangus esculentus*, and identified by Gill with this species, was found on the coast of Texas. I obtained a single specimen in the Saint John's River in the spring of 1878.

The Cuba Jurel.

(*Carangus fallax.*)

The occurrence of this species on our coast is vouched for only by a drawing, made by Mr. J. H. Richard, of a fish taken in South Carolina. Upon this drawing Holbrook founded his species *C. Richardii*. *Carangus fallax* occurs at various points in the West Indies, and it would be by no means impossible that a straggler should have found its way to Charleston. According to Professor Poey this fish has been prohibited from sale in Cuba from time immemorial, and with good reason, since many disastrous cases have followed its use as food.

The Scad.

(*Trachurus Plumierianus.*)

The Scad, known in New England as the Horse Mackerel, appears to occur in all temperate and tropical waters. Its distribution is given by Günther as extending "from the coasts of the temperate parts of Europe, along the coasts of Africa, round the Cape of Good Hope, into the East Indian seas, to the coasts of New Zealand and West America."

In Europe the Scad ranges north to the Drontjem's Fjord, latitude 65°, occurring also in abundance in the Mediterranean. On the coast of Holland it is known as the "Marse Banker" or "Hors." It is interesting to American ichthyologists, since the similarity of its habits to those of the Menhaden, so important in our waters, caused the latter fish to be called, among the early Dutch colonists of New York, by the same name. European writers describe them as occurring upon those coasts in schools of immense numbers, and it would seem that, although

their manner of swimming resembles that of the Menhaden, in their other habits they more closely resemble our own Bluefish. They are considered to be food-fishes of fair quality, and attain the length of about 12 inches. They are supposed to spawn about the same time as the Mackerel. Only a single specimen of this species has ever been taken on the east coast of the United States, this having been obtained by the Fish Commission from Southern New England in 1878. In California, according to Jordan, it is an abundant species, and is there commonly known as the Horse Mackerel. He remarks:

"It reaches a length of about a foot and a weight of less than a pound. It ranges from Monterey southward, appearing in the summer, remaining in the spawning season, and disappearing before December. It arrives at Santa Barbara in July and at Monterey in August. In late summer it is exceedingly abundant. It forms part of the food of larger fishes, and great numbers are salted for bait. As a food-fish it is held in low esteem, but whether this is due entirely to its small size we do not know. A similar species has been described from San Diego, under the name of *Caranx boops* Grd. It is unknown to us."

The Thread-Fish.

(*Blepharis crinitus.*)

This fish, also known as the Shoemaker Fish, is found along our coast from Cape Cod to the Caribbean Sea. In South America and also in California it is of no economic importance, but on account of its strange shape and the long thread-like appendages to its fins, which float behind it to the distance of five or six times its own length, it is often brought to the markets as a curiosity.

The Pompanoes (*Trachynotus carolinus*) and other species.

There are four species of Pompano in the Western Atlantic, very similar to each other in general appearance, but easily distinguished by differences in proportion and in the number of fin rays.

The commonest species, the Carolina Pompano, *Trachynotus carolinus*, has the height of the body contained two to two and two-thirds times in the total length. The length of the head, five to five and one-third times, one of the caudal lobes four times; it has 24 to 25 rays in the second dorsal, while the anterior rays of the true dorsal and anal fins, if laid backward, reach to the middle of the fin.

The Round Pompano (*T. ovatus*) has the height of the body contained two to two and one-third times in the total length; the length of the head, five to five and one-fourth times; one of the caudal lobes, three and a half to four times. In the second dorsal are from 18 to 21 rays, in the second anal from 16 to 19, while in the Carolina Pompano there are 21 to 22.

The African Pompano (*T. goreensis*) resembles in general form the

Round Pampano, though somewhat more elongate, while the head is larger, being contained four and a half times in the total length. The anterior rays of the dorsal and anal extend beyond the middle of the fin, if laid backward. In the number of the fin rays it corresponds most closely with the Round Pompano.

The Banner Pompano (*T. glaucus*) has a somewhat elongate body and a small head. It is much thinner than either of the other species. Its silvery sides are marked with four blackish vertical streaks; the best distinguishing mark is in the length of the first rays of the dorsal and anal, which extend back nearly to the tip of the caudal fin. The name Pompano, applied in this country to all of these fishes, is a Spanish word, meaning "grape leaf." The word in Western Europe is applied to a very different fish.

The Common Pompano.

The Common, or Carolina, Pompano (*Trachynotus carolinus*) occurs in both the Atlantic and Pacific waters of the United States. On our eastern coast it ranges north to Cape Cod, south to Jamaica, east to the Bermudas, and west to the Gulf of Mexico, at least as far as the mouth of the Mississippi River.

In our New England and Middle States it is a summer visitor, appearing in June and July and departing in September. Although it is at present impossible to ascertain the lower limit of its temperature range, it is probable that it corresponds very nearly to that indicated by a harbor temperature of 60° to 65°.

This species, like the Round Pompano, was described by Linnaeus from South Carolina, and never had been observed in any numbers north of Cape Hatteras until the summer of 1854, when Professor Baird discovered them near Great Egg Harbor. In his "Report on the Fishes of New Jersey" he states that he had seen them taken by thousands in the sandy coves on the outer beach of Beesley's Point. These, however, were young fish, few of them weighing more than half a pound. In 1863 he obtained both species in Southern Massachusetts, where in subsequent years they have been frequently captured.

"My first acquaintance with the Pompano (New England)," writes Professor Baird, "was in 1863, during a residence at Wood's Holl, where I not unfrequently caught young ones of a few inches in length. I was more fortunate in the summer of 1871, which I also spent at Wood's Holl; then the Pompano was taken occasionally, especially in Captain Spindle's pound, and I received at different times as many as 20 or 30, weighing about 1½ pounds or 2 pounds each. Quite a number were caught in Buzzard's Bay and Vineyard Sound in 1872."

It is a fair question whether the Pompano has recently found its way into northern waters, or whether its presence was unknown because nobody had found the way to capture it. When Mitchell wrote on the

fishes of New York in 1842 he had access to a single specimen which had been taken off Sandy Hook about the year 1820.

The spawning-times and breeding-grounds of these fishes are not well known.

Mr. S. C. Clarke states that in the Indian River they spawn in March in the open sea, near New Smyrna, Fla. It is supposed that those visiting our northern coasts breed at a distance from the shore. The eggs, like those of the Mackerel, being lighter than the water, float at or near the surface. The Pampanoes may, however, be truly migratory, seeking the waters near the equator in winter and following along a coastwise migration, north and south, in summer. They are rapid, powerful swimmers; their food consists of mullusks, the softer kinds of crustaceans, and, probably, the young of other fishes. S. C. Clarke remarks that they have been known to bite at a clam bait. Genio Scott remarks: "It is mullet-mouthed; never takes a bait except by mistake." Their teeth are very small and are apt to disappear with age. As seen in the New York market they rarely exceed 5 pounds or 6 pounds in weight. I quote in full the observations of Mr. Stearns:

"The common Pompano is abundant on the Gulf coast from the Mississippi River to Key West, and, as far as I can learn, is rare beyond this western limit until the Yucatan coast is reached, where it is common. It is considered the choicest fish of the Gulf of Mexico, and has great commercial demand, which is fully supplied but a few weeks in the year, namely, when it arrives in spring. The Pompano is a migratory fish in the Pensacola region, but I think its habits on the South Florida coast are such that it cannot properly be so classed.

"At Pensacola it comes in to the coast in spring and goes away from it in fall, while in South Florida it is found throughout the year. In the former section it appears on the coast in March in schools varying in numbers of individuals from fifty to three or four thousand, which continue to 'run' until the latter part of May, when it is supposed that they are all inside. Their movement is from the eastward and they swim as near to the shore as the state of the water will permit, very seldom at the surface, so as to ripple or 'break' the water, although sometimes while playing in shoal water they will jump into the air.

"Before any schools enter the bays certain ones will remain for days, or even weeks, in a neighborhood, coming to the beach during the flood-tide to feed on the shell-fish that abound there, and returning again to deeper water on the ebb-tide. The holes or gullies in the sand along the beach are their favorite feeding grounds on these occasions. Sharks and porpoises pursue the Pompano incessantly, doubtless destroying many. The largest numbers come in April, and sometimes during that month the first schools are seen entering the inlets, others following almost every day until about June 1, when the spring 'run' is said to be over. Every year they appear in this way at Pensacola and adjoining bays, although there are many more some years than others. As the

abundance is judged by the quantity caught, I think that the difference may lie more in the number of fishing days (pleasant ones) than in the real numbers of fish present. The sizes of Pompano that make up these schools are large or adult fish averaging 12 or 14 inches in length, and small fish (probably one year old) averaging 8 inches in length. The largest Pompano that I have seen measured 19½ inches in length, and weighed 6¼ pounds, the extremely large fish called Pompano, of two or three times that size, probably being another species. After entering the bays the schools of Pompano break up, and the fish scatter to all parts where the water is salt and there are good feeding-grounds. Except single individuals that are taken now and then, nothing is seen of Pompano until late in the fall, when they are bound seaward. In regard to its spawning habits nothing very definite has been learned. It has spawn half developed when it arrives and has none when it leaves the bays. Large quantities of the fry are seen in the bays all summer, which is some proof of its spawning inside. In June, 1878, I caught specimens of the fry, varying in size from three-quarters of an inch to 3 inches in length. Very many schools of these sizes were also observed in July and August, of the same and following years of 1879–'80.

"The schools of fry go to sea in August and September. The older or adult fish leave the coast in September and October in small schools, that are only seen and caught at the inlets where they happen to cross shoals or follow the beach. These Pompano of the fall are very fat and in every way superior to those caught in the spring. As before mentioned, the Pompano is found on the South Florida coast all the year. The sea-beach from Tampa Bay to Charlotte's Harbor seems to be its favorite feeding-ground, owing to the quantity of shell-fish that occur there. It does not form in large schools as in the Pensacola region, and therefore is not taken in such large quantities by seine fishermen.

"Smacks from Mobile and Pensacola sometimes go to Tampa Bay for them. I have been told that Pompano are caught at Key West in considerable quantities by hook and line, and I have known of a few being taken in that manner at Pensacola. It feeds entirely upon small shell-fish, which are crushed between the bones of its pharyngeal arch."

The Round Pompano.

(*T. ovatus.*)

The Round Pompano (*T. ovatus*), sometimes called the Shore Pompano, is at Pensacola known by the name "Gaff-topsail," and in the Bermudas by the name "Alewife." This fish is very often confused by market-men with the Carolina Pompano, and I have seen them sold together under the same name in the Charleston market, just as I have seen the young of four species of the herring family sold indiscriminately in New York.

The Round Pompano is cosmopolitan in its distribution, occurring in

the North and South Atlantic, in various parts of the Indian Ocean, and on the coasts of California and China. The young have been obtained in the harbor of Vineyard Haven, Mass. It is probable that the species is far more abundant in our waters than we now suppose it to be. Stearns remarks that it is obtained occasionally at Pensacola with the other species, but is never very common; is seen only in the spring, and is not valued as a food-fish. About the Bermudas they are sometimes very abundant, and in 1875 a school of them, numbering 600 or 700, was seined on the south shore of the islands. They are there considered most delicious fish.

The African Pompano.

(*T. goreensis.*)

This species was originally described from the island of Gorea, on the west coast of Africa, and was observed by the writer in 1876, and in 1877 was discovered in Florida. It is the largest of the Pompanoes. Two or three specimens, weighing from 15 pounds to 20 pounds each, have been sent from Florida to the New York market. One of these, taken at Jupiter Inlet, was sent by Mr. Blackford to the National Museum. In the Gulf of Mexico it is not unusual, being known at Key West as the "Permit."

Stearns remarks:

"This fish is rather common along the lower end of the Florida Peninsula, specimens being caught quite often in seines at Cedar Keys and at the Mullet fisheries of Sarasota and Charlotte's Harbor, and also at Key West. It is said to attain a considerable size, 15 or 20 pound specimens being common. It is not a choice food-fish when so large, and even smaller ones are comparatively dry and tasteless. I have not found it north or west of Cedar Keys."

The Banner Pompano.

(*T. glaucus.*)

This species is a member of the West Indian fauna and occasionally occurs at the Bermudas; it has lately been noticed on the Pacific side of the Isthmus of Panama.

The Pilot-fish.

(*Naucrates ductor.*)

The Pilot-fish, though of little or no economic importance, deserves passing mention, as it is so frequently referred to in literature. It is occasionally taken on our coast. Captain Atwood mentions a specimen which was taken in a mackerel net in Provincetown Harbor in October, 1858. A whale ship had come in a few days before and he supposes the Pilot-fish had followed it into the harbor.

"The Pilot-fish (*N. ductor*) is a truly pelagic fish, known in all tropical and temperate seas. Its name is derived from its habit of keeping company with ships and large fish, especially Sharks. It is the Pompilus of the ancients, who describe it as pointing out the way to dubious or embarrassed sailors, and as announcing the vicinity of land by its sudden disappearance. It was therefore regarded as a sacred fish. The connection between the Shark and the Pilot-fish has received various interpretations, some observers having perhaps added more sentiment than is warranted by the actual facts. It was stated that the Shark never seized the Pilot-fish, that the latter was of great use to its big companion in conducting it and showing it the way to its food. Dr. Meyen, in his 'Reise um die Erde,' states: 'The Pilot swims constantly in front of the led by the Pilot. When the Shark neared the ship the Pilot swam close Shark; we ourselves have seen three instances in which the Shark was to the snout or near one of the pectoral fins of the animal. Sometimes he darted rapidly forwards or sidewards as if looking for something, and constantly went back again to the Shark. When we threw overboard a piece of bacon fastened on a great hook the Shark was about twenty paces from the ship. With the quickness of lightning the Pilot came up, smelt at the dainty, and instantly swam back again to the Shark, swimming many times around his snout and splashing, as if to give him exact information as to the bacon. The Shark now began to put himself in motion, the Pilot showing him the way, and in a moment he was fast upon the hook.* Upon a later occasion we observed two Pilots in sedulous attendance on a Blue Shark which we caught in the Chinese Sea. It seems probable that the Pilot feeds on the Shark's excrements, keeps his company for that purpose, and directs his operations solely from this selfish view.' We believe that Dr. Meyen's opinion, as expressed in his last words, is perfectly correct. The Pilot obtains a great part of his food directly from the Shark in feeding on the parasitic crustaceans with which Sharks and other large fish are infested, and on the smaller pieces of flesh which are left unnoticed by the Shark when it tears its prey. The Pilot also, being a small fish, obtains greater security when in company of a Shark, which would keep at a distance all other fishesof prey that would be likely to prove dangerous to the Pilot. Therefore in accompanying the Shark the Pilot is led by the same instinct which makes it follow a ship.

"With regard to the statement that the Pilot itself is never attacked by the Shark, all observers agree as to its truth; but this may be accounted for in the same way as the impunity of the swallow from the hawk, the Pilot-fish being too nimble for the unwieldy Shark.

"The Pilot-fish does not always leave the vessels on their approach to land. In summer, when the temperature of the sea-water is several degrees above the average, Pilots will follow ships to the south coast of

*In this instance one may entertain reasonable doubts as to the usefulness of the Pilot to the Shark.

England into the harbor, where they are generally speedily caught. Pilot-fish attain a length of 12 inches only. When very young their appearance differs so much from the mature fish that they have been described as a distinct genus, *Nauclerus*. This fry is exceedingly common in the open ocean, and constantly obtained in the tow-net; therefore the Pilot-fish retains its pelagic habits also during the spawning season, and some of the spawn found by voyagers floating on the surface is, without doubt, derived from this species."*

The Medregal.

(*Zonichthys fasciatus.*)

This fish, called in Cuba the Medregal and in Bermuda the Bonito, has been observed in South Florida and along the coasts of the Carolinas. It is apparently exceedingly rare in the waters of the United States. In Bermuda it attains a length of two feet or more and is highly esteemed af a food-fish.

The Banded Rudder-fish.

(*Seriola zonata.*)

This species, known in South Carolina by the names "Jack-fish" and "Banded Mackerel," has been observed as far north as Salem and Beverly, Mass. Several specimens have been taken north of Cape Cod during the past forty years. It has also been found in South Carolina and Georgia, though rare in that region. It is a small fish, rarely exceeding 6 or 8 inches in length, conspicuous by reason of its brilliant and beautiful colors, and good to eat, though rarely saved by the fishermen who accidentally capture it. It is called the Rudder-fish on account of its resemblance to the Rudder-fish of the ocean. *Naucrates ductor.*

This fish was observed in the Gulf of Mexico by Mr. Silas Stearns, who writes:

"The Amber-fish is quite common off the West Florida coast, occurring in from 10 to 30 fathoms of water, on or near the 'Snapper Banks' throughout the year. It is a very active fish, swimming just below the water's surface, preying upon schools of small fish. It is rather shy of a baited hook, and but few are caught. It is a good food-fish. It attains a size of 40 inches length, and 15 pounds weight. Its average size but little more than half that."

The "Rock Salmon" of Pensacola (*Seriola bonariensis*) is recorded by Stearns as occasionally occurring near Pensacola in company with the preceding species, which it resembles in habits. It is caught with hook and line and is eaten. In his opinion, it attains a larger size than

* Günther's Study of Fishes, p. 444.

the Amber-fish. There is a third species of Amber-fish, of which the National Museum has received a single specimen from South Florida. It is closely related to the fish described by Cuvier under the name *Seriola Lalandii*. This species also occurs on the coast of California, where, according to Jordan, it is known under the names "Yellow-tail," "White Salmon," and "Cavasina."

Of the "Yellow-tail" Professor Jordan says:

"It reaches a length of 4 to 5 feet, and a weight of 50 to 60 pounds, and individuals of less than 15 pounds weight are rarely seen. It ranges from the tropical Pacific northward to the Santa Barbara and Coronados Islands, where it is found in great abundance in the spawning season, arriving in July and departing in early fall. It spawns about August 18. It is caught chiefly by trolling. It feeds on Squid and such fish as the anchovy and sardine. As a fresh fish it ranks high, although large individuals are sometimes coarse and tough. When salted and dried it is inferior to none on the coast, ranking with the Whitefish and Barracuda."

The Runner.

(*Elagatis pinnulatus.*)

This West Indian fish, known at Key West as "Skipjack" or "Runner," and at Pensacola as "Yellow-tail" or "Shoemaker," is, according to Stearns, "abundant on the western and southern coasts of Florida. At Pensacola it spawns in spring; the young fish are seen in July and August. It is found in the bays and along the sea beaches, seeming to prefer clear, salt water, swift currents, and sandy bottoms. It usually moves in small schools of a dozen or two individuals. It feeds upon small fishes and crustaceans. When pursued by larger fish it jumps repeatedly from the water, very much in the same manner as the Flying-fish, only its flights are much shorter and oftener repeated. This habit has given it the names of "Skipjack" and "Runner," at Key West, where it may be seen at almost any time. It is sometimes eaten at Key West, and at Havana is quite an important fish in the markets, being also exposed for sale at stands on the streets, cooked and ready for use."

The Leather-jacket.

(*Oligoplites occidentalis.*)

This fish, which is found throughout the West Indies and south as far as Bahia, has, since 1875, been several times observed between Florida and Newport, R. I. It is known to fishermen as the "Skipjack," sharing this name with a number of other scombroid fishes which leap from the water as they pursue their prey. It is one of the most beautiful and graceful fishes in our waters, but at present is of no economic importance.

NOTES ON M'CLOUD RIVER, CALIFORNIA, AND SOME OF ITS FISHES, BASED UPON A LETTER OF J. B. CAMPBELL, OF THE UNITED STATES FISH COMMISSION.

McCloud River, Shasta County, California, *May* 6, 1881.

Prof. Spencer F. Baird,

U. S. Commissioner of Fish and Fisheries, Washington, D. C.:

Sir: The United States Fishery is established, one and one-half miles from the junction of the McCloud with the Pitt, in a rough and mountainous country culminating in high limestone peaks on the east. Four miles above the fishery is the trout-rearing establishment, of which Mr. Myron Green is superintendent. East of the trout pond is a small creek or brook, running between limestone peaks. Three miles from the trout pond, and on the west side of the river, is a small farm belonging to Henry Mirey. One mile above Mirey's place is the home of the writer, consisting of a nice orchard and garden on the east side of the river, together with a beautiful creek that does not vary more than 4 degrees during the winter, and ranges from 53 to 57 degrees during the summer. For the next 65 or 70 miles there are neither white men nor Indians. There is a mill branch in summer, but none in winter. The entire country is mountainous. The river is very rapid. The temperature of the water at the United States Fishery, in the summer, is from 55 to 60 degrees at midday in the hottest weather. From the fishery up, the river gets one degree colder in about every 10 or 12 miles for the distance of 65 or 70 miles. There is a large spring that breaks out in the bed of the river, forming more than two-thirds of its volume. From there up the water becomes very warm, from 60 to 70 degrees. About three miles from the spring begins a series of three falls, each of which has a descent of about 50 to 60 feet, and is about two miles from the next. Under these falls there are a great many trout. I have caught one hundred in less than two hours. They are smaller than those lower down, averaging about one-half pound to one pound in weight. From these falls up, the water is quite still and sluggish (with the exception of about half a mile just above the falls, where it is very rapid) for many miles, traversing a lava country. There are plenty of trout above, and they are much larger than those below the falls, averaging about 8 to 10 pounds. Through seven miles of this sluggish water there are few trout, but as the water becomes more rapid small brook trout are plentiful. The river is about 130 to 140 miles in length, more or less, I should judge, but it has never been measured. Trout inhabit the river to the head-waters.

I will now endeavor to give you a description of some of the McCloud River fish, beginning at the mouth of the stream.

The first is known as the "rifle pike." Its color is darkish brown. It

has a small mouth and a comparatively small head. The flesh is very solid, but rather full of bones; yet the fish is considered excellent for the table. The "rifle pike" is found in the river through the last four miles of its course. It becomes very fat, and weighs from 2 to 5 pounds.

The second is called "whitefish." This splendid fish is so-called because of its white flesh. It prefers sluggish water, although I have seen it in rapid water about twelve miles above the mouth of the river. The "whitefish" has a large mouth and a very large head. The examples that I have seen varied from 4 to 28 pounds in weight, but larger ones have been caught.

The third is the "dolly varden" or "wye-dar-deek-it," a beautiful trout with golden spots on the back and sides, and with scales so small as to be hardly perceptible to the naked eye. The mouth is big and the head is large and not beautiful. The flesh is invariably red—a cherry red. It weighs from 2 to 15 pounds. It frequents the river from the junction to the spring, there being none above the spring and few near the river mouth. If one takes hold of the "dolly varden" it slips away nearly like an eel.

The fourth is the sucker, which inhabits the lower twelve or fourteen miles of the river. It reaches as much as 3 to 5 pounds in weight, averaging about 1 pound.

The fifth is the red-sided trout, or, as it is called in New York, the rainbow trout. I will mention only its habits, as you have undoubtedly seen many of them. It feeds almost entirely on the bottom of the river, but will take a fly through March, April, and part of May, as the river is then literally alive with insects. It also feeds on salmon eggs when the latter begin to spawn, and on old dead salmon, at which time it becomes very fat, and will rarely take a hook. It feeds very little during the spawning season, which is in the winter, from January 10 to April, and sometimes until May 1. Rainbow trout run up the small streams to spawn, sometimes; but the majority of them spawn in the main river. They spawn invariably on gravel beds, digging a small round hole in the gravel to correspond with their own lengths. The male accompanies the female, and lies close to her side, and when the female deposits her ova the male ejects his milt. They commence feeding immediately after spawning. I have caught them weighing two and one-half pounds. I could give you full details of their spawning, but I have not space.

The sixth is a bull-head, from 1 to 3 inches in length. It is very destructive to salmon spawn and the little salmon while they retain the umbilical sac.

Any time you should desire further particulars, send me a letter and I will answer it with pleasure. I have been writing to Seth Green for over two years, and have given him full particulars concerning the fish of this region and their habits.

If you want to know how the McCloud trout thrive in New York you

can apply to him, as I have supplied him with all that he has got from that river. He took some spawn from them this season.

I omitted to state that the "dolly vardens" are very destructive to other trout, or any kind of fish. They spawn in September and November. Their eggs are about one-half the size of those of the common trout. The fish are very difficult to obtain. They will live in a small place where the common trout would not. I have kept them in a pond, about 6 feet square, for a month, where the common trout would kill themselves in a short time. They appear to be more hardy. I have watched the salmon and the trout during their spawning more than any other man in this part of the country, as I have fished a great deal, and have been fishing longer than any one who takes any interest in the matter. I came here in 1855; I have caught hundreds and probably thousands.

J. B. CAMPBELL.

[NOTE.—The species referred to in Mr. Campbell's descriptions are the following: "Rifle Pike," *Gila* sp.; "Whitefish," *Ptychochilus oregonensis* (Rich.) Ag.; "Dolly Varden," *Salvelinus malma* (Walb.) Jor. & Gilb.; "Sucker," *Catostomus occidentalis* Ayres; "Red-sided Trout," *Salmo irideus* Gibbons; "Bull Head," *Uranidea* sp.—EDITOR.]

THE ORIGIN OF THE MENHADEN INDUSTRY.

By CAPT. E. T. DEBLOIS.

[NOTE.—In the following article, Captain DeBlois has thrown new light upon several long mooted questions, especially the date of the discovery of the value of menhaden oil, the origin of menhaden oil manufacture; the application of pressure in the manufacture of fish oil, and the invention of the purse seine, besides placing upon record an important series of observations upon the growth of the menhaden fishery within the past half century.—G. BROWN GOODE.]

In 1811 two men, one by the name of Christopher Barker, and the other John Tallman, commenced the business of making oil out of menhaden fish, with the use of two iron pots, upon the shore, a few rods south of what was then called the Black Point wharf, near Portsmouth, R. I. They boiled the fish in the pots or kettles, and bailed the fish and contents into hogsheads, putting on top the fish in the hogsheads pieces of board with stones on top, to press the fish down so that the oil would come on top, and also in order that the oil could be skimmed off. A man by the name of John Hunt was the oil man who skimmed off the oil, and put it up in barrels for market. It was sent to New York to market by a house or people that were doing business in Newport, R. I., by the name of Munroe, who were in the West India trade.

Barker & Tallman, it seems, found the oil business to be profitable, for in 1814 they added two more pots to their business, and the same fall two other men commenced the same business, by the name of Munroe, very near Barker & Tallman's works. The business was carried on

only in the fall, as the fish were too poor in the summer. The notable September gales of 1815, which were so very destructive on the New England coast, destroyed the above works, and washed them some 60 feet up on the land, from where they were located.

It is thought that the business did not get started again until 1818. It seems that in 1824 Mr. Barker conceived a new idea of cooking fish, and put his ideas into practice, by building a box 5½ feet high and 6 feet wide, and 8 feet long, with a fire-place or furnace in or on one end, and a copper pipe running from the fire furnace through the middle of the box, by which all the smoke and fire had to pass through the box. He usually put 60 pounds of fish in the box at a time, covering the same with water; this was called the "Bit Barker Fish Oil Factory." It was built on skids, and was conveyed from place to place by his oxen, using it most of the time on his farm, which was a mile from the shore, drawing the fish from the shore with his oxen. By this method he saved the water, and put it on his land as well as the scrap, which made his farm produce very large crops.

The first factory that was built to cook fish by steam in wooden tanks, as far as I know, was built by John Tallman; the second in the year 1841 on M'Gay's Point, Portsmouth, R. I. It had eight wooden tanks, holding 60 barrels of fish, and a flue boiler. The boiler was fed by a force-pump worked by hand. The next year Mr. Tallman joined Mr. George Lambert, of East Cambridge, Mass., and built a factory at the mouth of Merrimac River, Mass., and soon after Mr. Daniel Wells got Mr. Tallman's plan of factory and built one on Shelter Island, near Greenport, N. Y.

Mr. Charles Tuthill, of Greenport, was the first to express fish, for which we are very much indebted to him, as well as many other improvements that have been used by him in the business. The first purse-seine that was made, so far as I know, was made by John Tallman the first, and Jonathan Brownell and Christopher Barker, in the year 1826. It was 284 meshes deep and 65 fathoms long. The purse weight was a 56-pound weight, and the blocks were the common single blocks, and they had to reeve the end of the purse-line through the blocks, before they put the purse-weight overboard. The first time the seine was set, there were fourteen men to help; they set around what they called a 500-barrel school of menhaden, and, while they were pursing, the fish rushed against the twine so hard, that they twisted and snarled the twine around the purse line and weight to that extent, that the men could not gather the seine up, or get her into the boat again as they were, and, after they had worked six hours, and quarreled over the matter, they decided to tow or warp the seine ashore at high water, and, when the tide left the seine, they would be able to *unsnarl* it, which they did the next day. It was a number of days before they could muster courage to set her again, and, when they did, they set around a small school with better success.

The menhaden fisheries have been carried on here very extensively, catching them, before the oil factories were using many, expressly for bait and for the farmers, the farmers using them very freely, Mr. Abner Chase using, to my knowledge, 3,000 barrels a year some years (and his son has told me that his father used one year upwards of 4,000 barrels of menhaden fish) from 1849 to 1857. There were from 300 to 500 vessels a year after bait in Narragansett Bay, bank fishermen from New London, Conn., and mackerel and cod fishermen from Massachusetts and Maine, taking from 25 barrels to 150 barrels, some of them taking bait two or three times in a season, paying from 25 to 50 cents a barrel for them. There are not nearly as many vessels coming here now after bait, because they can get the bait at their own homes. Capt. Benjamin Tallman, of this place, formerly took the lead in the fishing business, at one time running four gangs, but, at present, the business is carried on more extensively in Tiverton, R. I., Joseph Church & Co. taking the lead. I commenced fishing in the year 1847 and fished with Capt. Nicholas Tallman, the most successful fisherman of his day. We fished twelve springs at Seaconnet Point, with traps and purse-seins, for every kind of fish that came along. It was my duty to be off on the water with a small boat with another man, and look down in the water around the trap, and to see if there were any fish that were likely to go in the trap. I observed that everything and all that came along in the spring always came from the southwest and went northeast invariably. The first fish that usually came along would be herring and shad, next tautog and flounders, and, in a few days, striped bass and sea-robins or wingfish. About the same time scup and sea bass, squid, menhaden, and mackerel came, and every kind of fish full of spawn except menhaden. I have taken a fish out of the trap many a time and put it in the water, and headed it up the river, and, as quick as I let go of it, it would turn at once and go down the river northeast, satisfying me that the first run of fish, of every kind, belongs east of Rhode Island. I never knew of a round mackerel to be caught three days after horse mackerel made its first appearance. I have seen a great many horse mackerel and have caught a great many, but never saw any signs of any spawn in them. When menhaden fish first come, they seem to be about 6 inches to 12 inches or more apart, very thin, not in schools, always going east, and in about a week after their first appearance they come along in large schools. That body of fish would be four weeks or more going by Rhode Island. The next body of menhaden that came along were smaller fish and came very slow and worked in the rivers. Horse mackerel and sharks were with them. We usually left the Seaconnet Point about the 10th of June and went pursing menhaden, and could always catch more than we could sell. In 1858 we had good fishing in the spring, but no menhaden in the summer, and, as there were a number of fishing vessels here waiting for bait, we persuaded them to go to New London, Conn. with us, which they did, and we found three schools

of menhaden off New London light, caught them and baited the vessels, and that was all that we could find. From there we went to Greenport, L. I., and did not find any there, although we heard of the fishermen hauling some ashore up at Jamesport and River Head. That I think was the dryest season for my business that I ever saw. Since then, most of the time, there has been plenty of menhaden; although I think it will average about one year in five, since I commenced, that fish are very scarce. In talking with some of the old fishermen, they say by what they hear the menhaden are as plenty now as they were when they first went fishing. They say that they then had seasons when they were very scarce, and also when they were very plenty. The fishermen here are all satisfied that the menhaden spawn in Rhode Island waters, and the little menhaden that we see here are hatched in Narragansett Bay. I went to Maine to build a pogie factory, the first one that was ever built in Maine, in November, 1863, and had it in running order June 10, 1864. The people of South Bristol, Me. told me that I would not have any trouble catching all the pogies that I should want in John's Bay, that the shores and bays were full of them, and that they plagued and bothered them, while they were fishing for mackerel, so much that they carried stones in their boats to stone or drive them away, but I did not find them so. The fish were very scarce in 1864. I got only 4,000 barrels. I cruised off-shore 20 miles and hailed vessels. They reported that they had not seen any fish. The same year Capt. Albert Grey, of Tiverton, started with four boats and a full gang to fish in Maine. He sailed from Rhode Island to Mount Desert, Me., but did not see a school of menhaden to set at, and returned without wetting his seine. Up to that time there had not been a purse-seine set in the waters of Maine.* Therefore, it is very evident that it was not the purse-seine that drove the pogies off the coast of Maine at that time. The first part of the fishing season of 1865 was not much better until the 4th of August. At that time a large body of very large and fat pogies came in from off-shore from the southeast. They were not in schools, but in one body. I fished between the islands of Damiscove and Monhegan. I, as well as my fishermen, thought that body of fish was eight miles wide, and it seemed to completely fill the space between those two islands, which is about ten miles. Capt. Washborn Clifford, of South Bristol, was freighting canned lobsters from the factory at Isle au Haut to Boston that season. He told me that the pogies seemed to be the whole length of the coast, and he did not run out of them until he got to Wood Island, a distance of one hundred miles. He said they made him think of a heavy shower of rain falling on the ocean; the ocean appeared to be alive with them. It may seem like a large story to tell,

* This statement needs some slight modification. Though menhaden were scarce in Maine in 1864, many thousands of barrels were caught. Purse-seines were used in these waters by Gloucester fishermen in search of menhaden and mackerel as early as 1857.

but, knowing the captain and knowing that, where I was fishing, the fish were in one body of about ten miles square, I have every reason to believe Captain Clifford's statement.

I honestly believe if the fishermen of Maine had had the experience in using the purse-seine in 1865 they have now, they would have taken out of the ocean between one and two millions of dollars' worth of wealth in pogies that season. I caught that summer upwards of forty thousand dollars' worth with one purse-seine. That body of pogies left the 1st of October, and worked gradually to the southeast. Everybody must admit that that large body of fish have lived and passed away long before this, as far as we know, without the least benefit to mankind, and I also believe that while the present fishing law is in force it will be the means of depriving the fishermen of Maine from taking hundreds of thousands of dollars' worth of fish from the ocean, that are about to pass away without being brought into use. There are two schools or families of pogies that usually come on the coast of Maine. The first follows the coast of Virginia along the shores to Maine, generally going into the rivers and bays. They usually get there about the 1st of June. They are the same kind of menhaden that we catch in the waters west of Cape Cod. They resemble Figure 1 in the Report of 1876–'77. About the middle of July to the 1st of August (and sometimes later) we have a school of pogies come inshore from the ocean, from a southeast direction, and make their first appearance to the east of Monhegan Island. These fish are very large and fat; resemble Fig. 3 in the Report of 1876–'77. They work gradually to the west, sometimes as far as Wood Island. These fish are never found to have any spawn in them. They generally leave the coast of Maine about the 20th of September. After cruising about some two or three days after they leave, and finding no fish, we start at once for Provincetown, Mass., expecting to fall in with them there; but we always find the pogies, that we get there, with spawn in them about 3 inches long. It seems that they cannot be the pogies that left the coast of Maine, as we never find the large fat fish in Maine with any sign of spawn, and all the pogies we catch at Provincetown in the fall have spawn in them. My idea is that the large fat pogies strike off the coast of Maine in the fall and do not make the shore again, unless they make the Carolina shore (if they make any shore), and the menhaden that we have passing along the New England coast in the fall are the same ones that went east in the spring. They always have spawn in them when they return in the fall, and it is not an uncommon thing to find spawn in them in Maine.

There is one more subject to which attention should be directed: I fished in Gardner's Bay, New York, five years or seasons from the spring of 1859 to the fall of 1864. On August 17, 1862, a school of very large fat menhaden came into Gardner's Bay, which made 14 gallons of oil to the thousand of fish without expressing. The next season, the 18th of August, the same kind of fish came again, and since that Mr. G. W.

Miles and Mr. Henry E. Wells have told me, that the same kind of fish have made their appearance in Long Island Sound, making 18 gallons of oil to the thousand fish. This is much fatter than any that I ever knew in Maine.

PORTSMOUTH, R. I., *January* 24, 1880.

FISH CULTURE IN NEW ZEALAND.

By R. J. CREIGHTON.

SAN FRANCISCO, CAL., *May* 13, 1881.

Hon. Professor BAIRD, *Washington, D. C.:*

DEAR SIR: I have to apologize for not returning your circular inquiries relative to fish-culture sooner; but, as I was only personally interested in the colonial work of fish-culture, I was unable to do so satisfactorily.

I have, however, received some information from New Zealand by the last mail which may prove interesting to you.

Mr. J. C. Firth, of Auckland, president of the Acclimatization Society there, writes to me to state that "Salmon have been caught in Wairoa River, about ten miles south of Auckland City. They have also appeared in other rivers, notably the Thames, in isolated cases. [The Thames is a large navigable river about fifty miles south of Auckland.] I must confess to some disappointment," he adds, "in not seeing more salmon, and I can only account for the circumstance by supposing that one of our native fish, a most voracious fellow, the 'kawai,' has devoured the young fish on the banks. I am glad to be able to report that the 'whitefish' from Lake Michigan have been seen in considerable numbers in Rotorua, Tarawera, and Taupo Lakes."

In explanation I may say that the first salmon ova (about 30,000) reached Auckland in 1874 or 1875, I am not sure which. Of these a few were hatched out and placed in the Wairoa. At the close of 1876, I had the honor to open a correspondence with you on the subject of a further shipment of salmon ova through Cross & Co., San Francisco, and this and a third shipment were made, the ova being pretty widely distributed north and south. I have had a note from Mr. Farr, secretary of the Acclimatization Society, Christ Church, New Zealand, in which he states that a salmon had been caught in one of the Canterbury rivers, and similar reports have come from more southerly districts. Mr. Farr also reports that 30,000 young whitefish had been hatched out in the society's hatching-house, and placed in a mountain lake, and were doing well.

The whitefish deposited in the large lakes of Otago, in the south of New Zealand, have not showed themselves, but, as the conditions are favorable, I have no doubt they are doing well.

A small shipment of salmon ova was made to Sir S. Wilson, of Victoria, I think, and they appear to have succeeded, as I noticed, some months ago, that a 7-pound fish was caught and had been served at a banquet to the Marquis of Normanby, the governor, and other guests.

From this you will gather that the acclimatization of United States fish in New Zealand and Australia had been successful. English brook trout, Eastern and California trout, have likewise been introduced with great success in New Zealand; also English carp.

Cat-fish were landed alive in Auckland from San Francisco, but what became of them I cannot say. I fancy that from an ignorant prejudice they were permitted to perish. These were forwarded by Dr. Hugh Craig, agent New Zealand Insurance Company for the Pacific coast. Mr. Craig has also made two attempts to send down edible crabs from this State by mail steamer. The first attempt failed; I have not heard the result of the second.

There are several private fish hatcheries in New Zealand; one owned by Mr. W. Johnson, of Opawa, in Canterbury, being the best known. He has introduced Eastern brook trout, and he wrote to me, that he had been successful in crossing the English and American trout, and that the young cross-breed grew faster and larger than either variety. Whether he has established a new variety of fish I cannot, of course, say.

In California, Mr. Redding, and the other gentlemen of the Fish Commission, will be able to inform you fully of what is being done by private enterprise. My own idea, however, is that far too little attention is paid to this matter by the State legislature, the appropriation for the fish commission being wholly inadequate, and I don't think very much is done by private individuals. They want to be educated up to the point of appreciating the industrial and economic value of the patriotic work in which you and the subordinate fish commissioners are engaged.

I inclose a newspaper clipping bearing upon this subject, which probably you have already seen.

I regret very much that I am not able to give you more explicit information on this subject, but these general statements will serve to show the importance of the United States Fish Commission to foreign countries.

I should add here that, whereas California salmon have succeeded in New Zealand and Australia, the English salmon, introduced much earlier, were a failure.

I am, very respectfully,

R. J. CREIGHTON.

AMERICAN BIRDS, ANIMALS, AND FISHES FOR NEW ZEALANDERS.

[Extract.]

The persistent efforts of New Zealand in the work of acclimatization deserves the utmost commendation. Half a century ago there were no domestic animals in that country, except a few herds of cattle and horses introduced by the early missionaries at the Bay of Islands, near the extreme north of the northern island. The celebrated discoverer, Captain Cook, had introduced sheep and swine half a century earlier, but the sheep very soon perished. The swine, however, increased rapidly, and became a nuisance to sheep-farmers after the colonization of the country, rewards being paid for their destruction as if they were noxious vermin. The colony was founded in 1840, and the natives had then barely abandoned their cannibal practices—desolating inter-tribal wars having lasted till within a few years of that date. Since then, the progress of the country has been the most remarkable on record. It has succeeded in acclimatizing nearly all the game birds of the old and new worlds. California quail are more plentiful there than in that State. Pheasants, grouse, partridges, etc., afford excellent sport, the several provinces competing with each other in the work of acclimatizing them. The song-birds of England are fully represented, and these, with the native songsters, make mountain and plain vocal the year round. Prairie chickens and mountain quail have likewise been introduced, sixteen of the latter birds out of twenty-two recently sent to Nelson by Robert J. Creighton, agent of the colony, having arrived there. These birds were forwarded from Emigrant Gap by J. B. Chinn, who took great interest in the matter. Deer-stalking is now possible in many parts of New Zealand, red and fallow deer having been introduced and increased wonderfully. The rivers are full of English and California trout, eastern trout being likewise represented. In the San Francisco Post particulars were published of a cross between eastern and English trout by Mr. Johnson, of Opawa, in the Canterbury province of New Zealand; the hybrid growing larger and faster than the pure fish of either variety. California salmon have likewise been acclimatized, and are in almost every river of any volume in the islands. English salmon are established in New Zealand, also salmon trout. The latter fish has increased very fast, and is now purchasable in most of the markets of the colony. But the great interior lakes of the country are comparatively without fish; indeed, in several of them and tributary rivers fish-life can scarcely be said to exist. To remedy this defect two attempts were made to stock the lakes with whitefish from Lake Michigan. These attempts failed in the colony from local causes. This year, however, another effort is being made on a much larger scale than formerly. Mr. Creighton has arranged for the shipment of over

20,000,000 whitefish eggs from the fish-hatching establishment of Frank N. Clark, Northville, Mich., by the mail-steamer Australia. The eggs will be packed in mountain ice, and carefully watched during the voyage. On their arrival at Auckland they will be transferred to a colonial steamer, preparations having been made for their reception and distribution throughout the colony. Mr. Clark kindly forwarded to Mr. Creighton models of his patent hatching-boxes, and these are already in the colony, so that no hitch will occur in this regard. Mr. Clark telegraphed from Omaha on the 15th that the eggs had been shipped in good condition, and would arrive in San Francisco on the 19th. Mr. Clark came with the shipment from Northville to Omaha, to insure against any damage or accident en route. The friends of acclimatization in this State will be gratified, no doubt, at the success of the experiment. Of the Australian group of colonies New Zealand is more closely identified with this country than any other.—(*Frank Leslie's Illustrated Newspaper.*)

CARP IN THE HUDSON RIVER.

By E. E. SHEARS.

COXSACKIE, GREENE COUNTY, NEW YORK,
January 26, 1881.

Prof. S. F. BAIRD,
U. S. Fish Commissioner, Washington, D. C.:

DEAR SIR: Will you please send me your last report. If you have anything special on the carp, please send that also. Are there any carp in the Hudson River? I find in "Transactions of the American Institute," dated 1850, page 397:

"Mr. MEIGS. We are pleased to see among us Captain Robinson, of Newburgh, who brought the carp from England several years ago, thus conferring a great benefit upon his country by adding a fish before that unknown in our waters.

"Captain ROBINSON. I brought the carp from France about seven years ago, put them in the Hudson River, and obtained protection for them from our legislature, which passed a law imposing a fine of $50 for destroying one of them. I put in gold-fish at the same time. Now some of these carp will weigh two pounds, and some of the gold-fish, which are a species of the carp, are quite large, some of them being pure silvery white. Both kinds are multiplying rapidly."

I notice that the gold-fish are quite plenty in the river in this vicinity; also a fish about the size and shape, which is called a silver-fish, but they do not correspond to Captain R.'s description of the silver-fish. These are nearly or quite as dark as a rock-bass. I have seen none that would weigh over one pound and a half. When caught in fykes by the fishermen they are usually pronounced unfit to eat and thrown back in the river.

However, last fall I saw them peddled through the streets, and the fishermen told me they could catch scarcely any other kind, and they sold as well as perch or bass. I have not had an opportunity to taste any of them, therefore am no judge of their flavor.

Respectfully,

E. E. SHEARS.

SUGGESTIONS TO FISH CULTURISTS.

By GARRICK M. HARDING.

WILKES-BARRE, PA., *January* 16, 1880.

Prof. SPENCER F. BAIRD,

U. S. Commissioner of Fisheries:

MY DEAR SIR: In reply to your esteemed favor of recent date, permit me to say that for ten years past and upwards public attention has been largely directed throughout the Northern States of the Union to the subject of fish-culture. Formerly the interest felt in this matter was mostly confined to sportsmen, but the rapid increase of population, the growing necessities for food, added to the fact that our forests were fast passing away, our mountain streams and wooded lakes denuded of their shade and converted into other than purely nature's uses, have, altogether, awakened a general interest in the subject. While the actual number of those personally engaged in fish-culture is limited, yet the whole mass of our people may be said to be looking now with encouraging favor upon the enterprise.

Individuals associate together in a sort of *quasi* corporation and purchase ponds and inland lakes, rent creeks and even small rivers, stock them with fish of various kinds, always observing, however, adaptabilities both as respects the waters and the fish. Thus sport and supply go hand in hand. Nor are the owners or controllers of such waters alone benefited. These ponds and inland lakes are the sources which make up the rivers that flow, often in large volume and for great distances, through the country to the sea. They too become stocked, teem with choice fish. The public at large thus have brought within their reach, without cost, the sport and supply which, in the beginning, seemed designed only for the few.

In order to have the most satisfactory results from this system of buying or controlling ponds and inland lakes, experience has shown that the outlets should be secured by a galvanized-wire screen of a mesh not greater than three-quarters of an inch in size. If brook trout, black bass, or pickerel be the fish with which any such water is stocked, the small fry, appearing generally the first year but surely after the second, will find their way through the meshes of the screen in numbers sufficiently great to stock abundantly in three or four years every commingling and suitable water below. Brook trout, however, should never be

placed in a pond or small inland lake along with either black bass or pickerel. They are the fish of fishes, and deserve to have a domain exclusively to themselves, always excepting the minnow and possibly the shiner. These latter are the natural if not necessary food for brook trout. Indeed, the culture of all three together is always advisable.

Black bass and pickerel may be placed together in any natural or artificial reservoir large enough to be dignified as a pond, though the former will thrive much better where the water is not less than from 12 to 30 feet deep, with rocky shores and a rocky or gravel bottom; the latter will thrive in a less depth with mud for a bottom and marshes for surroundings. Cultivated together, each will prey upon the other, but the black bass will get ahead at last.

The easiest and of course the best, indeed the only, fish to cultivate in rapid and mountain streams is the brook trout. And yet in the States of Pennsylvania and New York, or at least in the newer portions of them, the streams best adapted for this purpose are absolutely valueless for the cultivation of any sort of fish whatever. Most of the creeks and small rivers rise and flow through forests of pine and hemlock. They are dammed up at intervals and set back in some instances for distances varying from one to four miles. Great bodies of water are thus accumulated, and into these, especially in the winter time, millions of logs are thrown, some 12 feet in length with a diameter from 8 to 40 inches, and some anywhere from 12 to 40 feet in length with diameters corresponding. Spring time comes, and in addition to the melting snows and the usual rains of the season, which of themselves commonly swell these streams into torrents, the gates of the dams are hoisted and these logs plunge along through gorges at a frightful rate down towards the places of lumber manufacture, tearing away banks and overhanging shade, filling up natural holes for fish rest and hiding, and destroying in one way and another all fish-life outright. Even with such floods of natural and stored waters the weight of lumber is often so great that a "drive" of only a few miles is attained. The dams are closed again, myriads of little fish that have taken refuge in overflows or pools formed for the moment outside of the main channels, die as the waters recede. The logs *jam*, as it is called, and, piling one upon another from shore to shore for miles, they sink down crushing to death the large fish in great numbers. This work of incidental fish-destruction is repeated from day to day, and will continue to go on until lumbering of this sort shall be at an end. In the mean time all attempts at fish-culture in streams of this character may as well be abandoned. Success will be impossible.

I have thus, sir, given you my views and the results of my observations appertaining to the subject which, I am rejoiced to see, you have so much at heart.

Very respectfully,

GARRICK M. HARDING.

A GERMAN VIEW OF THE AMERICAN SECTION IN THE BERLIN FISHERY EXHIBITION.

By DIRECTOR HAACK.

[Translation.]

[From "Referat des Herrn Direktor Haack über die Internationale Fischerei-Ausstellung zu Berlin." (Report of Director Haack on the International Fishery-Exposition at Berlin). Metz, 1880.]

Everything which America had sent was on a magnificent scale. The American exhibit was distinguished by the enormous number of objects placed on exhibition, giving not merely a faint image of the fisheries, but a complete view of the fresh-water and salt-water fisheries, for the greater part in original representations. The American exhibit was moreover distinguished by the neat workmanship of all the objects and by an exemplary arrangement which in all particulars showed the practical man. It is impossible to enter into details, as this would take up our entire space, for the American department was a complete fishery-exposition in itself.

We shall, therefore, only cast a rapid glance at the numerous boats, both originals and models, examine a little more closely the "dories," so much admired by all connoisseurs, learn to know the portable canoes of the Indians and trappers made of bark and skins, admire the truly magnificent scientific collection filling several rooms, and finally devote some time to the department of pisciculture.

Much of the apparatus on exhibition was already known to us, as for about three years we have imitated the Americans in this respect; thus we know the Holton apparatus, the Wilmot hatching-funnel (really, as we now learn, invented by the well-known American pisciculturist, Fred. Mather, who twice already has safely transported eggs of the California salmon to Europe); the Seth Green shad apparatus, &c. But lost in astonishment we stand before the large model of the Fish-hawk, a large steamship specially constructed by the American Government for purposes of pisciculture. This steamship contains, both in its interior and on its sides, hundreds of large pieces of apparatus for hatching fish eggs. The steam-engine partly serves for pumping up the water, thus producing a constant current of water through all the apparatus inside the vessel, and partly for moving to and fro in the water the apparatus attached to the sides of the vessel, thus vivifying the germs of the eggs. This government steamer visits the principal fishing-stations during the spawning-season of the shad—a fish closely resembling our "May-fish" (*Alosa*)—takes up hundreds of millions of impregnated eggs, develops them further in the manner described above, and, when the young fish have been

hatched, sets them out in the most suitable places. This steamer also goes out to sea and hatches millions and millions of the finest salt-water fish.

With all our piscicultural efforts we must confess that we felt very small when viewing this grand American exhibit; and the magnificent results obtained in America are a sufficient guarantee that this is no "American humbug." For the present we can certainly do no better than to strain every nerve and imitate the example set us by the Americans.

PEAT-BOGS AS FISH-PONDS.*

[From "Oesterreichisch-Ungarische Fischerei-Zeitung," volume IV, No. 1, Vienna, January 1, 1881.

The proprietor of the establishment *Fichthof* near *Stettin* has shown how easily and with what little expense fish-ponds can be made, and how well it pays to stock them with young fish; for his pond, with an area of one-fourth acre, not only supplies his large family with food, but also yields him a very fair revenue. Nine years ago he commenced to dig peat from a very barren piece of ground. The peat was found to rest on a layer of lime, which he likewise utilized. When the spring-water began to overflow the ground, he got a peat-raising machine, with which he took out all the lime and peat. The very first year, this thoroughly exhausted peat-bog and lime-pit was stocked with one-year old pike, perch (*Perca fluviatilis*), bleak, tench, and bastard carps (*Cyprinus carassius*). During the first five years these fish were well protected; and four years ago he commenced to catch fish which were fully matured and particularly fat. Thus he has, among other fish, caught with a spear a very fat pike weighing 9¼ pounds, which certainly must have been one of the fish with which the pond was stocked in the beginning, which shows that it had increased about one pound in weight per year. The pond in question has now an area of one-fourth acre and an average depth of 12 feet. The banks are very steep down to the bottom, and the water is spring-water, which, through subterranean channels, comes from the neighboring pine forest of *Leba*. The water flows off through a draining ditch; but fish cannot escape in that way, as the outflowing water has not sufficient depth. The pond seems to contain an abundance of fish-food. The water rests on the characteristic lake-bottom; the steep banks, going from bottom to top, show first a layer of marshy peat about 6 inches thick and utterly worthless; on this rests the marsh-line—a mass of sweet-water shells—3 feet thick; next comes a layer of very valuable peat, 7 feet thick, and on the top of this a layer of drift sand, 2 feet thick, overgrown with grass. The sides of the pond therefore contain lime, peat, and sand. From these sides, perhaps also from the supply of forest water entering the pond through subterranean channels, the fish obtain their food; for they are

*Torfgruben als Fishteiche.—Translated by HERMAN JACOBSON.

not fed, and it is scarcely probable that the excrement of geese, which during summer wander about the banks and swim on the pond, and consequently feed altogether on grass, furnishes any food for the fish. Some water also flows into the pond above ground; along the edges grow *Glyceria fluitans* and *Juncus*, and *Conferva* rest upon the water. Fishing in this pond is carried on by means of bow-nets, a seine, and spears. Large pike and perch do their share to prevent the overcrowding of the pond. This pond furnishes another proof that every exhausted peat-bog may be used as a fish-pond, if it contains water. Such bogs, however, must admit of fishing; no edges of peat should therefore be left, and the refuse should not be thrown into the pond, but carried away and used as manure. Such ponds, which have formerly been peat-bogs, are found in many places, and are absolutely useless as long as not stocked with fish. Every farm might have fish-ponds, if people would take more interest in this matter, and would display more energy in transforming these exhausted peat-bogs, overgrown with poisonous weeds and full of parasites, into fish-ponds, yielding a revenue.

CASTRATING FISH.*

By HERR WEDDIGE.

[From "Deutsche Fischerei-Zeitung," volume iv, No. 1, Stettin, January 4, 1881.]

The writer of these lines has years ago spoken to fishermen and advised them to make experiments regarding the possibility and probable success of the castrating of fish by removing the roe or the milt. This matter has also been spoken of in the "Deutsche Fischerei-Zeitung," p. 483, but, as far as known to the writer, no such experiments have been made. It is probably not very difficult to remove the roe or milt from live fish, but of course it will be necessary to exercise great caution in doing it. The belly would have to be ripped open with a very sharp knife, the roe or milt would have to be loosened very carefully without injuring any other organs, and the cut would finally have to be sewed up with the greatest care. It is probable that the wound of a fish treated in this manner will heal very soon. The nutricious matter which would otherwise have served for forming roe or milt will certainly cause a more rapid increase of flesh and fat, and therefore an equally rapid increase in the weight of the fish. For such experiments young, but full-grown, fish should be selected (perhaps two or three year old trout) whose generative matter has not yet been fully developed (the time for trout would therefore be April and May). None should engage in such experiments but those who possess the necessary leisure and knowledge. If such experiments should prove successful, the castrating of a large number of fish will possibly prove an advantage to

* "*Kastrirung von Fischen.*"—Translated by HERMAN JACOBSON.

the owners of closed fish-ponds. It is of course impossible to say in advance whether such advantage would be commensurate to the trouble and probable loss of fish by unsuccessful operations. Only the more valuable fish, *e. g.*, trout, and perhaps carp, would be fit subjects for such experiments.

NOTE.—We have received the following letter on the same subject:

"Referring to the question whether it is possible to castrate fish, in Nos. 52 and 53 of the 'Deutsche Fischerei-Zeitung,' I would observe that the idea is not a recent one. Thus the author of '*Wohlbewährte Fischgeheimnisse oder deutlicher Unterricht von der grossen Nutzbarkeit der Fischerei, wie auch von der Fische Natur und Eigenschaft; nebst einer Anweisung, wie sie bequem zu fangen, und zu welcher Zeit man solche am Besten halte*' (Well preserved fish-secrets or plain instructions regarding the great usefulness of fisheries, also regarding the nature and quality of fish; accompanied by hints how to catch fish in the easiest manner, and during what season they can best be kept); 2d and improved edition, Nuremberg, by George Bauer, 1758, in the chapter entitled 'On the Castrating of Fish' (*von der Verschneidung der Fische*), gives the following extract from '*Histoire de l'Academie des Sciences* 1742, *Observations de physique V*': 'Mr. Sloane, the former President of the Royal Society of London, has written to Mr. Geoffroy, towards the end of December last, that an unknown person had revealed to him the secret how to castrate fish and make them grow fat thereby. This person, who originally was nothing but a net-maker, and had formerly lived 5 or 6 miles from Mr. Sloane's country place, had built up a considerable trade in fish by his skill in managing them. This strange communication excited the curiosity of the naturalist, and the fish merchant offered to show him the experiment. He took eight bastard carps (*Cyprinus carassius*), a species of small carp which had recently been brought to England from Hamburg, and placed them into two large vessels filled with water, which was renewed once or twice during the experiment. He began by opening one of these eight carps with a knife, and showing Mr. Sloane the ovarium which opens into that part which is called 'the cloaca.' He thereupon cut open another carp, laid bare the ovarium, and closed the wound with a piece of a black hat. The carp which had been cut were placed with the other six, but did not seem able to swim as well as the rest. They were finally all thrown into a small pond in Mr. Sloane's garden, which is supplied with water from a neighboring river, and where, he thinks, they were still living at the time when he wrote to Mr. Geoffroy. Further information is not given. This man, whose name is Samuel Tull, promised Mr. Sloane, that in spring he would invite him to a dish of cut fish, which were said to excel other fish in flavor as much as a capon a common rooster, and as a cut ox an uncut one. As there is much similarity between land animals and fish, it is probable that castrating has the

same effect upon the latter, and Mr. Sloane thinks that this discovery should be further investigated, and that it may serve to give a finer flavor to fish, and to prevent their too rapid increase in fish-ponds, where their number is too large as it is.'"

WEDDIGE.

OSNABRÜCK, *December* 15, 1880.

THE INTRODUCTION OF STRIPED BASS INTO CALIFORNIA.

By S. R. THROCKMORTON.

SAN FRANCISCO, *November* 12, 1880.

Hon. SPENCER F. BAIRD,

U. S. Commissioner Fish and Fisheries

Smithsonian Institution, Washington, D. C.,

DEAR SIR: I have from unavoidable causes been compelled until now to defer addressing you upon the subject of the transporting to, and acclimatizing in, our waters the striped bass of your coast.

I have long had the impression, that the great bay of San Francisco, together with the bays of San Pablo and Suisun connecting with it, and the number of creeks running into them, affording a variety of qualities and conditions regarding temperature and saline properties, together with feeding material, would be well adapted to the propagation and growth of the striped bass.

Having this in view, I last year opened a correspondence with Mr. Livingston Stone upon the subject of attempting the transfer of some small fish at the time of the bringing on of the lobsters. Many difficulties presented themselves in the matter of obtaining the small fry of the striped bass, which resulted in my suggesting to Mr. Stone the probability of obtaining them in the extreme headwaters of the Navesink or Shrewsbury River, in New Jersey. Mr. Stone succeeded in obtaining a small number at the place designated by me, and, with his usual skill, brought them safely to this coast and deposited them at the head of the straits of Carquinez, the turning point of the fresh and salt water.

Some six or seven months after the time of placing in the water I heard that one of 8 inches in length had been taken in the bay of Monterey, which is about one hundred miles south of this, and is an open roadstead on the Pacific Ocean. All of the circumstances were of so doubtful a character that I gave the rumor but little attention, until about the 1st of July, eleven months after the planting of the young fry, at the time about 1½ inches in length, in the straits of Carquinez, there was brought to me a very handsome striped bass taken in this harbor, measuring 12½ inches in length and weighing one pound. The fish was in the highest condition, the milt full and ripe, and the flavor fully up to the best specimens of the fish at the East. The exceedingly

rapid growth, indicating the adaptability of the waters of this bay to this development, together with the immense amount of shrimps, which abound in this bay and furnish abundant food, have, I must acknowledge, infused me with almost an enthúsiasm to have this valuable fish brought here in sufficient numbers to insure the breeding of them. I have heard of some experiments having been made in breeding them artificially. If that can be done, we might, of course, bring them out as easily and in as great numbers as we now do shad, and my object in now writing you is to ascertain the probability of such an effort being successful.

If it cannot be done our only course must be to enlarge upon and extend the experiment of last year. The small fry can be obtained in the fresh-water heads of the Navesink, the Raritan, the Passaic, the Hackensack, and, in fact, all of those small rivers which flow from the New Jersey coast into the Atlantic and the bays emptying into it. Will you be so kind as to give the matter some thought and let us have the benefit of it? The shad are a success, and we feel satisfied that so soon as they shall have reached such numbers as to insure contact we shall breed them in abundance.

With much respect, I remain, yours truly,

S. R. THROCKMORTON,
Chairman California Fish Commission.

THE SELF-PICKER.

By FRANK N. CLARK.

NORTHVILLE, MICH., *February* 17, 1881.

DEAR SIR: Responding to your request for my opinion concerning the operations of self-pickers, I submit the following:

The name "Self-picker," as applied to any ova hatching apparatus yet devised, claiming the ability within themselves to completely separate the dead eggs from the living, is a misnomer.

All self-pickers, so called, are employed in hatching eggs by what is known as the bulk method, and the principle on which they are operated is the same in each. This principle is based on the supposition that all ova of confervoid growth, which are, for the most part, lighter than the live eggs, can be driven or separated from the latter by a properly adjusted current of water. But, when we consider that a small percentage of the dead eggs possess no greater buoyancy than the live ones, and consequently a current of water, strong enough to drive off all of the former, must necessarily take with it some of the latter, the impossibility of devising any apparatus that will be a complete self-picker or separater will be readily seen. Nevertheless, I consider the method of bringing forward the eggs in bulk far superior to any of the hatching-box or tray systems now in use. It is practicable, however, to develop

in bulk only such eggs the fry of which are able to swim out of the mass of eggs when hatched, or are light enough to be thrown out by the current of water. No objections on this score can be raised to this plan for hatching ova of the whitefish (*Coregonus albus*), or of the shad (*Alosa sapidissima*).

Of the several appliances which have been invented for hatching eggs by the bulk method, those most prominent, and which are undoubtedly the best, are the Mather & Bell cone, as improved by Major Ferguson, and the Chase hatching-jar.

The cone has been used exclusively for hatching the shad, while the jar has been confined to the whitefish work, with the exception of a single experiment with shad-eggs, where it was found to work very well, but must be tried still further before it can claim equality with the cone for shad work.

The cone, too, with the "Clark" gate attachment, would, in all probability, equal the jar for hatching eggs of the whitefish, but has not been sufficiently tested in this direction to warrant its introduction without further experiment.

The jar, although but recently introduced, has largely displaced the hatching devices for whitefish work hitherto in use, and, when its merits are more fully understood and appreciated, will, I think, entirely supercede all other appliances for the work in question. With its use one man can take care of 20,000,000 ova, and thus its great economy, as compared with any hatching-box ever invented, will be readily apparent. This great difference in its favor may be credited to the fact of its being so constructed and operated as to collect for the most part the eggs of confervoid growth at or near the surface of the mass of eggs, whence they are easily removed. Thus it will be seen that they are "partial separaters," but not "self-pickers."

But this partial separation of the dead eggs is a merit of no small proportions, as but little time is required for their removal when massed together, while the small percentage of dead eggs remaining unseparated is rendered powerless to harm the living ones by the constant current of water, which keeps the whole mass of eggs in ever-changing motion, and thus protects the latter from the contaminating influences of the former. It may be stated, as an actual fact, that where water of a temperature not exceeding 40° F. is used, in consequence of which the confervoid growth is comparatively slow, a large percentage of dead eggs may be allowed to remain or collect in a jar without jeopardizing the lives of the remainder; but the practice of removing all extraneous eggs collecting at the surface is to be commended.

The method employed by Mr. Chase, inventor of the jar in question, for removing these eggs, is to augment and thereby strengthen the current of water in the jar to that degree necessary to force the mass of eggs upward until the surface is on a level with the mouth of the jar, the gate being raised in the mean time to allow the surface eggs to float

off. But the most careful manipulation will fail to prevent the escape of many good eggs with the bad ones when this plan is pursued, as the line of separation between the two is not distinctly drawn.

I have found that a great saving of time, as well as eggs, can be effected by using a glass siphon to draw off the surface eggs. I have also used the siphon very successfully while operating the cone in shad hatching. No nicety need be observed in this process, as all eggs thus separated can be placed in a separate jar, when, in a few moments, a solid layer of eggs of confervoid growth will collect on top and can be readily siphoned away unattended with the loss of any good eggs, while the latter can remain in the jar to be manipulated as before when necessary. Other ways of assisting the jars to eliminate the extraneous eggs have been tried, but I have found the siphon plan to be by far the most expeditious and need not result in the loss of a single good egg by throwing away. This plan, then, consists essentially in collecting the surface eggs from the jars as often as may be necessary or desirable and condensing the same into one or more jars, from whence the most of the dead eggs can be removed without disturbing the good ones; by thus completing, with the aid of the siphon, the natural operations of the jar in separating the bad eggs from the good ones, the tedious and expensive process of picking out the dead eggs with nippers is done away with.

In any method of incubating eggs wherein they are stationary, as with the hatching boxes and trays, a slimy coating will be found adhering to the eggs which must be washed away as often as may be necessary; and for the same reason, the trays, boxes, and troughs also will require an occasional cleaning. And again, when the eggs are hatching, the trays require a daily manipulation to dislodge a portion of the fry and shells which will not escape through the meshes. All this work is unnecessary when the jar is used; the constant motion imparted to the eggs by the current of water keeps them bright and clean, and when hatching the fry and shells are, by the upward current, drawn out through the mouth of the jar into a tank for their reception, the gate at the mouth of the jar being removed during the hatching season.

The following suggestions may be of service in operating the jar:

It should be full of water, and, with its accessories, in position and in running order before the introduction of the eggs; but, while they are being introduced, it is better to interrupt the water supply of the jar being filled, which will prevent the eggs from flowing against and clogging the wire gate.

The rubber connecting-pipe should extend down inside the glass tube below the level of the water in the jar, to keep the water free from air-bubbles.

Eggs are sometimes found bunched together on their arrival from the spawning grounds; these should be broken up before their entrance into the jar, as the movement of the water therein is too gentle to accomplish this end.

The little projections or feet at the conical end of the glass tube should be accurately ground so as to compel a uniform current to flow from all points of the base of the tube. The capacity of the jar in question may be stated as 150,000 eggs of the *Coregonus albus*.

At the present writing, I have a jar containing 40,000 eggs of the whitefish, which are hatching very rapidly. These are the oldest eggs on hand, and their speedy development was brought about by an accident. The main conducting pipe sprung a leak, which interrupted the water supply of the jar for a few moments only; but as soon as the water was turned on again from another pipe, these eggs immediately began hatching by the thousands. This shows that when the eggs are nearly developed, their constant movement in the jar must not be checked if it is thought advisable to detain the appearance of the fry for the longest possible period. These eggs, however, were nearly mature, and the fry therefrom are lively and vigorous.

Yours, very truly,

FRANK N. CLARK.

Prof. S. F. BAIRD,

U. S. Commissioner of Fish and Fisheries, Washington, D. C.

COAL ASHES AS A MEANS OF RAISING MACKEREL IN PURSE SEINES.

By S. J. MARTIN.

Sometimes, when there is a large school of mackerel in the seine, they are heavy on the bottom of the seine, so that it cannot be easily handled. In such a case heave a bucket of coal ashes in the seine, and that will bring the mackerel to the surface. Captain Coas, of schooner John S. McQuinn, told me he had three hundred barrels of mackerel in his seine and they lay so heavy on the twine that he could not move the seine with twelve men hauling on the twine. He threw a bucket of coal ashes in it, the mackerel came to the surface, and they could then easily haul the seine. All the vessels that have tried it say it works well. The cook saves the coal ashes.*

METHOD OF USING WILLARD'S PATENT POCKET FOR MACKEREL.

By S. J. MARTIN.

Capt. S. J. Martin, Gloucester, Mass., writes in his journal, under date of June 30, 1881:

"I will explain how *Willard's Patent Pocket* is used for mackerel. In the first place, there are two out-riggers 9 feet long and 4 inches through;

*NOTE.—Ashes have been used, so Mr. Merchant tells me, for several years, but is thrown outside of the seine instead of into it, as Captain Martin thought. The object is to frighten the fish by making the water white, when they rise to the surface. The same result is obtained by the menhaden fishermen by giving a few quick turns of the propeller. The fishermen call it "whirling them up."—J. W. Collins.

one of the out-riggers goes into the rail at the main rigging. There is an iron plate on the rail. What the fishermen call a 'goose neck' is on the inner part of the out-rigger that goes down through the iron plate on the rail. The forward out-rigger is forward of the fore-rigging and is fixed the same as the after one. There is a guy on the end of the out-riggers to keep them steady. The guy on the after one leads aft, and the guy on the forward one leads forward. The length, the distance between the out-riggers on board of a ninety-ton vessel, is 32 feet. The mouth of the bag is 33 feet wide; it is fastened on the out-rigger to within 4 feet of the end. There are stops on the out-riggers to fasten the pocket on. The inner part of the pocket is made fast to the rail of the vessel between the two out-riggers. There is a block on the outer part of the out-rigger. A block is made fast to the rigging, half way up the mast, that forms a tackle to the outer end of each out-rigger. When the seine has mackerel in it, the pocket is made fast to the inner part of the seine, the out-riggers are lowered down to the edge of the water and the mackerel are poured into the pocket. The pocket will hold two hundred and fifty barrels of mackerel. It is made of stout twine, 1½-inch mesh. Some of the vessels have dressed a whole trip out of the pocket. When the mackerel are in the pocket, the seine is ready for a new school. All the seiners are having pockets made. All rigged, the pockets cost $80. The size of the pocket is 8 fathoms deep, 32 feet wide, 14 feet long.

FIRST APPEARANCE OF FISH AT GLOUCESTER, 1881.

By CAPT. S. J. MARTIN.

The herring came May 5, and were small. May 6, the large herring came. May 13, the first mackerel caught in trap at Kettle Island, thirteen in number. The first tautog were caught May 13 in the trap at Kettle Island. The first perch caught May 8. Flounders and sculpin first caught April 21. The small pollock came in the harbor May 2. Alewives first caught May 13. The first menhaden caught off Long Branch May 6, by Gallup & Holmes' steamers, of New London; 800 barrels taken in one day. Finback whales have been plenty since the first of April. Schooner Alice, of Swan's Island, was in Boston Monday, with 30,000 mackerel, caught off Block Island. The mackerel are coming east fast and are of good size. Pollock are plentiful at Chatham. Two vessels got 35,000 pounds each with seines; they were schooling on top of the water, the same as mackerel.

GLOUCESTER, *May* 18, 1881.

ON THE PROPAGATION OF THE STRIPED BASS.

By E. R. NORNY.

ODESSA, DEL., *May* 9, 1881.

Prof. SPENCER F. BAIRD:

I have read with great satisfaction a correspondent's account in the New York Herald of the 2d instant in regard to your success in the Albemarle Sound; but I find the propagation of the striped bass or rock is still as much of an enigma as ever. The correspondent says the fishermen think they have discovered the place where they spawn.

Let me here offer a suggestion. Since my last communication to you, I have conversed with a gentleman interested in the striped bass, who informed me that he conversed with a gentleman from Wilmington, Del., who said to him that on one occasion he saw a large female bass cast her spawn on the boulder rocks in the vicinity of Wilmington Creek, Del. This is the location where we supposed those fish spawn from the fact that it is here that the young fry are first numerously seen. The Delaware State side of the stream at this point is full of loose boulder rocks, and the gentleman said the fish seemed to remain and defend her spawn. I have tried to verify the truth of this statement, but have been unable to ascertain the gentleman's name. The only doubt is, the general turbid condition of the waters of the Delaware would make it difficult to see any considerable distance below the surface; but, perhaps, in the dry season of May at low water he may have seen what is here represented, for those large fish venture in very shallow water. If such is the case, then your Albemarle fisherman should look for rocky or bouldery bottom to find the spawning ground of the striped bass.

I have not altered my opinion that the true mode to propagate these fish is to pen up the immature fish and retain them until their maturity, both male and female.

I now have in captivity a sixty-pound female, which I have had so confined for nearly two weeks under very unfavorable circumstances. The pond contains an area of about half an acre, but is shoal, the greater portion not being over one foot deep; but there are several rods square that contain from three to five feet in depth. The misfortune of this pond is that it takes an extra high tide to put water in it, and the fish has only had fresh water in the pond but once since its capture. If providence favors me with a few tides to fill the pond with a fresh supply of water, I have no doubt I shall carry it over the spawning time, which, I think, will be by the 1st of June. The object is not to propagate the fish, but to prove the feasibility of thus keeping them and to determine the time of their maturity. If they can thus be kept, and I have not

the least doubt of it, I could have furnished this season to a pond both male and female fish sufficient, with the same success in hatching as with shad, to have produced 100,000,000 young fish of a species second to no other in our seaboard waters. As it was, all the large fish, after being captured, were turned loose again to propagate in their own natural way.

These fish, in confinement, will require a liberal supply of food. I have placed in the pond a supply of live herring, as I found on cutting one open, weighing about 35 pounds, that its maw contained two large-sized herring, one more than half digested, the other in perfect form.

I hope to have the good fortune to capture this fish on the 1st of June, and find it past maturity, and be able to again return it to the bay.

Yours, &c.,

E. R. NORNY.

A GEORGIA CARP POND.

By ABEL A. WRIGHT.

GRIFFIN, GA., *May* 14, 1881.

Prof. SPENCER F. BAIRD:

ESTEEMED SIR: The sketches of my fish pond failed to reach you, and I am sorry, because I wanted you to see them and tell me how you like my plans, &c. This pond I built before I ever heard of a carp, or saw a drawing as in Hessel's work, the ideas being my own. The carp are genuine beyond a doubt, because there is no earthly chance for any fish to get into the pond, no fish being in the streams it empties into, and nothing but beautiful clear springs feeding it only a few hundred feet off; and there is a large fall, about one-quarter of a mile below, that no fish can get above, the water falling perpendicularly over a shelving rock. I was extremely particular in regard to this matter. If I go to Florida in the fall, I will superintend getting a fine lot of aquatic plants and send them to you at my own expense. The carp feed ravenously on moss that grows in the water; I had boxes of it shipped to me, and I know what I am talking about. I notice one thing, the carp love to spawn among the thick masses of weeping-willow roots that grow out in the water; they have great masses of fine fibrous roots. I have seen hundreds of pounds in the water near the bank where they would spread out in the water for yards around; and another thing, a little black caterpillar about an inch or more long, with yellow spots, comes on the weeping willow and drops into the water. I have seen the large carp lie watching for them, and, when one falls in the water, the carp would take him in out of the wet; and also grasshoppers and earth-worms thrown into them. I buy damaged crackers from Atlanta by the barrel

and feed with them; I get them at two cents per pound; I have five barrels now just received. If feeding well will make them grow they shall have it. It is funny to see the little fellows eating small crumbs; sometimes a dozen will be around one small crumb and stick to it until it is all gone. I delight in sitting at my pond watching the fish, and they seem to know me and my wife from strangers, judging from their actions. I will make another drawing of my pond and send you if you did not get the one sent. Nothing will please me better than to meet you and talk fish. I have exterminated the bull-frog and snake tribe, and all is quiet on the lake at night now, and not a ripple is made by his snakeship seeking the tempting frog or fish.

ABEL A. WRIGHT.

MOVEMENTS OF YOUNG ALEWIVES (?) (POMOLOBUS SP.) IN COLORADO RIVER, TEXAS.

By TARLETON H. BEAN.

The United States National Museum has recently received from Mr. J. H. Selkirk, of Matagorda, Texas, two small alewives, measuring about one inch in length, which are wonderfully like the fry of the common alewives of the Potomac and other northern rivers. They have been compared directly with fry of nearly the same size taken opposite Washington, and, while we cannot say positively that they are identical with the "branch" alewife or herring, yet we believe that they are the same species. Mr. Selkirk sent the fish to Professor Baird, thinking that they might prove to be shad, which, indeed, they resemble. I quote from his letter to the Commissioner the details of his observations upon them:

"MATAGORDA, TEX., *April* 20, 1881.

"To the FISH COMMISSIONER,

"*Washington, D. C.:*

"DEAR SIR: I inclose two small fish. Please inform me what species they are. My reason for asking is, that some few years ago there were some shad placed in the Colorado River at Austin, and, as I have never seen any shad, and these were taken out of the same river near its mouth, I thought it possible they were shad. They were all going up stream, and in innumerable quantities. I am not exaggerating when I say, I walked along the bank for a mile, and as far as I went they were in sight as thick as anywhere, and still coming, the school being about two feet wide.

"This river empties into Matagorda Bay a short distance from where I saw them."

From the fact that these young herring were discovered near the mouth of the river ascending the stream in dense masses, one would infer that they were the young of some anadromous species, such as the "branch"

or "glut" alewife of the Potomac, rather than of the golden shad of the Mississippi Valley, which is essentially a fresh-water species. We are not obliged to depend upon this observation of habits, however, since a comparison of the fry with the young alewives previously mentioned leaves little doubt as to their identity. It is probable that they were hatched in the waters of the Gulf of Mexico adjacent to the Colorado mouth some time in February or March of this year. It is to be hoped that specimens of the adult alewives, and any other herring-like fishes that may be found in the Colorado and other tributaries of the Gulf, will be secured and forwarded to Prof. S. F. Baird, United States Commissioner of Fish and Fisheries, Washington, D. C., in order that the progress of introduction may become known. If those fry observed by Mr. Selkirk are young alewives, it is almost certain that they were introduced into Texas with the shad. It is well known that the newly-hatched alewife is small enough to come in through the gauze bottom of a hatching-box, which will not allow the escape of shad eggs or fry. The alewife, moreover, is hatched earlier than the shad, and is always on hand in advance to unite destinies with its larger relative, even to the extent of being carried thousands of miles and deposited in waters never seen by its progenitors. In this way, it seems to me, one of the great lakes, and some of the lakes of New York, were stocked with alewives in the effort to introduce shad; at all events, they first appeared in those waters after the attempts with shad were made.

U. S. National Museum,

Washington, May 6, 1881.

NOTES ON THE LIFE-HISTORY OF THE EEL, CHIEFLY DERIVED FROM A STUDY OF RECENT EUROPEAN AUTHORITIES.

BY G. BROWN GOODE.

I. Number of species of eels and the method of classification.
a. Gunther's views. *b.* Dareste's views.
II. Number of species of eels in America.
III. Geographical distribution of the eel.
IV. General note on habits.—Professor Baird.
V. Introduction of eels into new waters in the United States.
VI. Günther on the life-habits of the eel.
VII. Benecke on the general natural history of the eel.
VIII. Ancient beliefs concerning the reproduction of the eel.
IX. Search for and discovery of the female eel.
X. Hunt for the male eel and discovery of Syrski.
XI. How to distinguish male and female eels.
a. Internal characteristics.—Benecke and Syrski.
b. External characteristics.—Jacoby.
XII. Questions as to the viviparous nature of eels.—Benecke.
XIII. Hunt for young eels.—Jacoby.
XIV. Undoubted normal reproductive habits of eels.—Benecke.
XV. Do male eels leave the sea and enter fresh water?
XVI. Strange mistatements concerning the breeding of the eel.
XVII. Benecke on the movements of young eels.
XVIII. Observations of Dr. Hermes in 1881, on the conger.
XIX. Jacoby's tour to Comacchio in 1877 and his conclusions.
XX. A list of the most important books and papers concerning the eel and its habits of reproduction.

I. Number of species of eels.

a. Günther's views.

There is no group of fishes concerning the classification and history of which there is so much doubt as the eel family; an infinite number have been described, but most are so badly characterized or founded on individual or so trivial characters that the majority of ichthyologists will reject them.*

In his Catalogue of the Fishes in the British Museum, Dr. Günther has claimed to retain those as species which are distinguished by such characters that they may be recognized, though he remarks that he is by no means certain whether really specific value should be attached to them, remarking that the snout, the form of the eyes, the width of the bands of teeth, &c., are evidently subject to much variation. In his more recent work he remarks," Some twenty-five species of eels are known from the coast waters of the temperate and tropical zones."

*Günther, Catalogue of Fishes British Museum, viii, p. 24.

b. DARESTE'S VIEWS.

Other recent writers have cut the knot by combining all of the eels into three or four, or even into one, species, and it seems as if no other course were really practicable, since the different forms merge into one another with almost imperceptible gradations. In his monograph of the family of Anguilla-formed fishes* M. C. M. Dareste remarks:

"Dr. Günther has recently published a monograph of the apodal fishes in which he begins the work of reducing the number of specific types. The study of the ichthyological collection of the Paris Museum, which contains nearly all of Kaup's types, has given me the opportunity of completing the work begun by Dr. Günther, and of striking from the catalogue a large number of nominal species which are founded solely upon individual peculiarities.

"How are we to distinguish individual peculiarities from the true specific characters? In this matter I have followed the suggestions made with such great force by M. Siebold in his History of the Freshwater Fishes of Central Europe. This accomplished naturalist has shown that the relative proportions of the different parts of the body and the head vary considerably in fishes of the same species, in accord ance with certain physiological conditions, and that consequently they are far from having the importance which has usually been attributed to them in the determination of specific characters.

"The study of a very large number of individuals of the genera *Conger* and *Anguilla* has fully convinced me of the justice of this observation of Siebold; for the extreme variability of proportions forbids us to consider them as furnishing true specific characters.

"I also think, with Siebold, that albinism and melanism, that is to say, the diminution or augmentation of the number of chromatophores are only individual anomalies and cannot be ranked as specific characters. Risso long since separated the black congers under the name *Muræna nigra*. Kaup described as distinct species many black Anguillas. These species should be suppressed. I have elsewhere proved the frequent occurrence of melanism and albinism more or less complete in nearly all the types of fishes belonging to this family, a fact especially interesting since albinism has hitherto been regarded as a very exceptional phenomenon in the group of fishes. This also occurs in the *Symbranchidæ*: I have recently shown it in a specimen of Monopterus from Cochin China presented to the museum by M. Geoffroy St. Hilaire.

"I must also signalize a new cause of multiplication of species; it is partial or total absence of ossification in certain individuals. This phenomenon, which may be explained as a kind of *rachitis* (rickets), has not to my knowledge been noticed, yet I have found it in a large number of specimens. I had prepared the skeleton of a *Conger* of medium size, the bones of which are flexible and have remained in an entirely

* Comptes rendus of the Academy of Sciences, Paris.

cartilaginous state. Still it is not necessary to prepare the skeleton to determine the absence of ossification, for we can establish this easily in unskinned specimens by the flexibility of the jaws. It is very remarkable that this modification of the skeleton is not incompatible with healthly existence, and that it does not prevent the fish in which it is found from attaining a very large size.

"Those fishes in which ossification is absent are remarkable by reason of the great reduction of the number of teeth, which, although the only parts which become hard by the deposit of calcareous salts, remain however much smaller than in individuals whose skeletons are completely ossified.

"We can thus understand how such specimens could present characters apparently specific, and that they should have been considered by Kaup as types of new species. These considerations have led me to reduce, on an extensive scale, the number of species in the family.

"So, in the genus *Anguilla*, I find but four species: *Anguilla vulgaris* occurring throughout the northern hemisphere, in the new world as well as the old. *Anguilla marmorata* and *A. mowa* of the Indian Ocean, and *Anguilla megalostoma* of Oceanica.

"There are at least four distinct types, resulting from the combination of a certain number of characters; but the study of a very large number of specimens belonging to these four specific types has convinced me that each of these characters may vary independently, and that consequently certain individuals exhibit a combination of characters belonging to two distinct types. It is therefore impossible to establish clearly-defined barriers separating these four types.

"The genus *Anguilla* exhibits, then, a phenomenon which is also found in many other genera, and even in the genus *Homo* itself, and which can be explained in only two ways: Either these four forms have had a common origin and are merely races, not species, or else they are distinct in origin, and are true species, but have been more or less intermingled, and have produced by their mingling intermediate forms which coexist with those which were primitive. Science is not in the position to decide positively between these alternatives."

II. Number of species of eels in America.

It is the disposition of American ichthyologists, at least, to accept the views of Dareste, and to consider all the eels of the northern hemisphere as members of one polemorphic species. Günther is inclined to recognize three species in North America: one the common eel of Europe, *Anguilla vulgaris;* one the common American eel, *Anguilla bostoniensis*, which he finds also in Japan and China; and the third, *Anguilla texana*, described and illustrated by Girard, in the Report of the United States and Mexican Boundary Survey, under the name of *A. texana*, which, he remarks, is scarcely specifically distinct from *A. bostoniensis*, from which it differs only in the greater development of the lips. The distinction

between *A. bostoniensis* and *A. vulgaris*, as stated by him, consists chiefly in the fact that the dorsal fin is situated a little farther back upon the body, so that in the former the distance between the commencement of the dorsal and anal fin is shorter than the head, while in the latter it is equal to or somewhat longer than it. This character does not appear to be at all constant.

III. Geographical distribution of the eel.

We may therefore provisionally assume the specific identity of the eels of the old and the new world, and define their distribution of the common eel somewhat as follows: In the rivers and along the ocean shores of Eastern North America, south to Texas and Mexico, and north at least to the Gulf of Saint Lawrence, but absent in the waters tributary to Hudson Bay, the Arctic Sea, and the Pacific; present in Southern Greenland (?) and Iceland, latitude 65° north; on the entire coast of Norway, from the North Cape, latitude 71°, southward; abundant in the Baltic and in the rivers of Russia and Germany, which are its tributaries, and along the entire western and Mediterranean coasts of Europe, though not present in the Black Sea, in the Danube or any of its other tributaries, or in the Caspian; occurring also off Japan and China and Formosa; also in various islands of the Atlantic, Grenada, Dominica, the Bermudas, Madeira, and the Azores.

IV. General note on habits. [Professor Baird.]

The habits of the eel are very different from those of any other fish, and are as yet but little understood.

"This, so far as we know," writes Prof. Baird, "is the only fish the young of which ascend from the sea to attain maturity, instead of descending from the fresh to the salt water. Its natural history has been a matter of considerable inquiry within a few years, although even now we are far from having that information concerning it that would be desirable, in view of its enormous abundance and its great value as a food fish.

"The eggs of the eel are for the most part laid in the sea, and in the early spring, the period varying with the latitude, the young fish may be seen ascending the rivers in vast numbers, and when arrested by an apparently impassable barrier, natural or artificial, they will leave the water and make their way above the obstruction, in endeavoring to reach the point at which they aim. Here they bury themselves in the mud and feed on any kind of animal substance, the spawn of fish, the roes of shad, small fish, &c. At the end of their sojourn in the ponds or streams they return to the sea, and are then captured in immense numbers in many rivers in what are called fish-baskets. A V-shaped fence is made, with the opening down-stream into the basket, into which the eels fall, and from which they cannot easily escape. This same device, it may be incidentally stated, captures also great numbers of other fish,

such as shad, salmon, and other anadromous fish, to their grievous destruction.

"As might be expected, however, the Falls of Niagara constitute an impassable barrier to their ascent. The fish is very abundant in Lake Ontario, and until artificially introduced was unknown in Lake Erie. At the present time, in the spring and summer, the visitor who enters under the sheet of water at the foot of the falls will be astonished at the enormous numbers of young eels crawling over the slippery rocks and squirming in the seething whirlpools. An estimate of hundreds of wagon-loads, as seen in the course of the perilous journey referred to, would hardly be considered excessive by those who have visited the spot at a suitable season of the year.

The economical value of the eel as a food fish has been well established, and it is now greatly sought after for introduction into the localities where, for some physical or other reason, it is unknown. The advantages, as summed up by a German writer, are, first, that an eel will live and grow in any water, however warm, and whatever be the general character of the bottom, though it prefers the latter when muddy and boggy; second, the eel requires no special food, but devours any thing, living or dead; it is an excellent scavenger, feeding upon dead fish, crabs, etc., as well as upon any living prey it can secure; third, but few conditions can interfere with its development, while it grows with very great rapidity, being marketable at the age of three years; fourth, the young, on account of their hardiness, can be transported in a crowded condition, and to any distance, with very little risk of destruction. These considerations are, in the main, well established, and there is no question but that the eel can be introduced in many waters to advantage, supplementing the earlier inhabitants. It has been planted in the waters of the upper lakes and the Mississippi River; in the latter they have reached an advanced development. It is, however, a very undesirable inmate of rivers in which fish are taken by means of gill-nets, the destruction of shad and herring in the waters of the Susquehanna and others further south being enormous. It is not unfrequent that when a gill-net is hauled up, the greater part of the catch consists simply of heads and backbones, the remainder being devoured by myriads of eels in the short time the net is left out. The spawning shad are considered by them a special delicacy, and are found emptied at the vent and completely gutted of the ovaries. Sometimes a shad, apparently full, is found to contain several eels of considerable size. They do not seem to be very destructive of living fish of any magnitude, although the young fry are devoured with gusto."*

V. Introduction of eels into new waters in the United States.

In describing the geographical distribution of the eel it was stated that it occurs in the rivers and along the ocean shores of North America.

* MS. note by Professor Baird.

This being the case, as might be supposed, there are many inland lakes and streams of the United States in which this fish does not occur; for instance, in the chain of the great lakes above Niagara Falls and in the upper waters of other streams in which there are considerable obstructions. The cutting of canals in various parts of the country has, however, produced a great change in their distribution; for instance, it is stated by Mitchell* that eels were unknown in the Passaic above the Great Falls until a canal was cut at Paterson, since which time they have become plentiful in the upper branches of that river. They have also been placed in many new localities by the agency of man. Concerning this Mr. Milner remarks:

"The eel (*Anguilla bostoniensis*), appreciated in some localities and much vilified in others, is another species that has been frequently transplanted. It is pretty evident that it never existed naturally in the chain of great lakes any higher up than Niagara Falls, although specimens have been taken in Lakes Erie and Michigan. Their existence there is with little doubt traceable to artificial transportation.

"A captain of a lake vessel informed me that it was quite a common thing some years ago to carry a quantity of live eels in a tub on the deck of a vessel while on Lake Ontario, and they were often taken in this manner through the Welland Canal. He said that it was a frequent occurrence on his vessel when they had become tired of them, or had procured better fishes, to turn the remainder alive into the waters of Lake Erie.

"In 1871 Mr. A. Booth, a large dealer of Chicago, had an eel of four pounds weight sent him from the south end of Lake Michigan, and a few weeks afterward a fisherman of Ahneepee, Wis., nearly 200 miles to the northward, wrote him that he had taken a few eels at that point. It was a matter of interest to account for their presence, and a long time afterward we learned that some parties at Eaton Rapids, Mich., on a tributary of the lake, had imported a number of eels and put them in the stream at that place, from which they had doubtless made their way to the points where they were taken. The unfortunate aquarium-car in June, 1873, by means of the accident that occurred at Elkhorn River, released a number of eels into that stream, and about four thousand were placed by the United States commission in the Calumet River at South Chicago, Ill., two hundred in Dead River, Waukegan, Ill., and three thousand eight hundred in Fox River, Wisconsin."†

They have since been successfully introduced into California.

VI. Günther on the life-habits of the eel.

Concerning the life-history of the eel much has been written, and there have been many disputes even so late as 1880. In the article upon

* Transactions Lit. and Phil. Soc. New York, I, p. 48.

†Report U. S. Fish Commission, p. 2, 1874, 526.

ichthyology, contributed to the Encyclopedia Britannica, Günther writes:

"Their mode of propagation is still unknown. So much only is certain, that they do not spawn in fresh water; that many full-grown individuals, but not all, descend rivers during the winter months, and that some of them at least must spawn in brackish water or in deep water in the sea; for in the course of the summer young individuals from 3 to 5 inches long ascend rivers in incredible numbers, overcoming all obstacles, ascending vertical walls or flood-gates, entering every larger and swollen tributary, and making their way even over *terra firma* to waters shut off from all communication with rivers. Such emigrations have long been known by the name '*Eel-fairs*'. The majority of the eels which migrate to the sea appear to return to fresh water, but not in a body, but irregularly, and throughout the warmer part of the year. No naturalist has ever observed these fishes in the act of spawning, or found mature ova; and the organs of reproduction in individuals caught in fresh water are so little developed and so much alike, that the female organ can be distinguished from the male only with the aid of a microscope."

VII. Benecke on the general natural history of the eel.

In attempting to present a review of this subject I am sure I cannot do better than to translate at length a communication just received from my friend Dr. Berthold Benecke, professor in the University of Königsberg:

"The coloration of eels varies greatly not only in different localities, but in the very same places: the back may be dark blue or greenish black; the sides, lighter blue or green; the belly, white; sometimes the back is only slightly darker than the sides; sometimes there are olive green individuals with a golden-yellow band upon their back, sometimes they are entirely golden-yellow and, very rarely, entirely white. The eel lives in deep quiet waters with muddy bottom; it burrows out holes and tunnels in which it rests quietly during the day, while at night it comes out in search of food. From the deck of a steamer passing through rivers or canals one may see upon the banks, which are laid bare by the waves produced by the motion of the vessels, numerous eels with half of their bodies projecting from their lurking holes.

"The eel feeds upon all kinds of small water-animals, and may be found on the spawning places of other fish in great troops, going there for the purpose of feeding upon the eggs. They feed also upon crabs at the period when they are shedding their shells, and have in many localities in Germany completely exterminated them. Since the eel is everywhere known as a greedy robber, many accounts have been given of their wanderings, in which they have made their way into the pea-patches to feed upon pease. The oldest reference of this kind is that of Albertus Magnus, who remarks in his book of animals, published at Frankfort-on-the-Main in 1545: 'The eel also comes out of the water in

the night time into the fields, where he can find pease, beans, or lentils.' This statement was contradicted in 1666 by Baldner,* who writes concerning the eel: 'They eat fish, do not come on the land, and do not eat pease, but remain in the water always, and are nocturnal animals.'

"Forthwith, new statements were made which tended to show the actuality of the wanderings of the eels in the pea-patches. For instance, Bach, in his 'Natural History of East and West Prussia,' published in 1784, maintained that eels frequently were caught in the pea-patches in the vicinity of the water, where they fed upon the leaves or, according to other accounts, upon the pease themselves, and continues: 'These movements explain the paradoxical fact that in Prussia and Pomerania fish have been caught upon dry land by the use of the plough, for the peasants, in warm nights when the eels are in search of the pease, towards morning when it is not yet day, make furrows with the plough between them and the water, and these are the nets in which the eels are caught. Since the eel moves with ease only upon the grass, its return to the water is cut off by the soil which has been thrown up. The peasants consider it as a sign of approaching stormy weather when the eels come out of the water upon dry land.'†

"A person writes to me from Lyck: 'In storms they come out into the pea-patches, and at this time people spread sand or ashes around, and thus prevent their return.' Such tales are even now numerous in the newspapers.

"The small size of the gill-opening makes it possible for the eel to live for a long time out of the water, and it is possible that in their wanderings over moist meadows they may find places in which there are snails and other desirable food. The explanation of their supposed wanderings over the pea-patches is, that the eels, which have been found at different times in the fields or meadows, have been lost by poachers, who threw them away in their flight. Many times dead eels have been found upon meadows over which they have swam, the meadows being flooded, and, in spite of the nearness of the water, have afterwards been unable to return to it.

"Although the activity and tendency among young eels to wander is very great, yet we cannot believe in the wandering of adult eels over wide stretches of land. According to Spallanzani, in Comacchio, where for many centuries an eel fishery of immense extent has been carried on, these fish are found in numerous ponds and lagoons, the fishermen have never yet seen an eel wandering over the land; and once when, on account of the drying up of the water, the eels died by the thousand,

*Recht natürliche Beschreibung und Abmahlung der Wasser-Vögel, Fischen, vierfüssigen Thier, Insecten und Gewirm, so bey Strassburg in den Wassern sind, die ich selber geschossen und die Fisch gefangen, auch alles in meiner Hand gehabt. Leonhard Baldner, Fischer und Hagmeister in Strassburg gefertigt worden 1666. Manu script. (Cited by von Siebold, Süsswasserfische von Mitteleuropa. Leipzig, 1863.)

†A live and active eel, a few days since, was dug out from a depth of five feet in the soil of Exeter, N. H.—Gloucester Telegraph, Oct. 26, 1870.

not one of them made the attempt to escape by a short journey over land into the neighboring lake or into the river Po.

"The eel occurs in all our waters, with the exception of small, rapid brooks. The fishermen distinguish many varieties based upon the differences in the form of the head or color and the varying proportions in the length of the body and tail; and the older ichthyologists have followed their opinions without sufficient reason.

"By rapid growth the eel attains the length of 24 to 30 inches, and often a greater size. On account of their fat, which is very highly flavored, and the absence of bones, they are everywhere valued, and are caught in various ways. The most profitable method of capture is in eel weirs and eel baskets and in traps by the use of nets, and on hooks they are also caught in great quantities. In winter many eels are taken with spears on the shelving shores where they lie buried in the mud in a state of torpidity. In this fishery very often more are wounded than captured, and, in addition to the large eels, great quantities of small ones are taken."

VIII. Ancient beliefs concerning the reproduction of the eel.

The reproduction of the eel, continues Benecke, has been an unsolved riddle since the time of Aristotle, and has given rise to the most wonderful conjectures and assertions. Leaving out of question the old theories that the eels are generated from slime, from dew, from horsehair, from the skins of the old eels, or from those of snakes, and the question as to whether they are produced by the female of the eel or by that of some other species of fish, it has for centuries been a question of dispute whether the eel is an egg-laying animal or whether it produces its young alive; although the fishermen believe that they can tell the male and female eels by the form of the snout. A hundred years ago no man had ever found the sexual organs in the eel.

Jacoby has remarked that the eel was from the earliest times a riddle to the Greeks; while ages ago it was known by them at what periods all other kinds of fishes laid their eggs, such discoveries were never made with reference to the eel, though thousands upon thousands were yearly applied to culinary uses. The Greek poets, following the usage of their day, which was to attribute to Jupiter all children whose paternity was doubtful, were accustomed to say that Jupiter was also progenitor of the eel.

"When we bear in mind," writes Jacoby, "the veneration in which Aristotle was held in ancient times, and still more throughout the middle ages—a period of nearly two thousand years—it could not be otherwise than that this wonderful statement should be believed and that it should be embellished by numerous additional legends and amplifications, many of which have held their own in the popular mind until the present day. There is no animal concerning whose origin and existence

there is such a number of false beliefs and ridiculous fables. Some of these may be put aside as fabrications; others were, probably, more or less true, but all the opinions concerning the propagation of the eel may be grouped together as errors into three classes:

"(I.) The beliefs which, in accordance with the description of Aristotle, account for the origin of the eel not by their development from the mud of the earth, but from slimy masses which are found where the eels rub their bodies against each other. This opinion was advanced by Pliny, by Athenæus, and by Oppian, and in the sixteenth century was again advocated by Rondelet and reiterated by Conrad Gessner.

"(II.) Other authorities base their claims upon the occasional discovery of worm-like animals in the intestines of the eels, which they described, with more or less zealous belief, as the young eels, claiming that the eel should be considered as an animal which brought forth its young alive, although Aristotle in his day had pronounced this belief erroneous, and very rightly had stated that these objects were probably intestinal worms. Those who discovered them anew had no hesitation in pronouncing them young eels which were to be born alive. This opinion was first brought up in the middle ages in the writings of Albertus Magnus, and in the following centuries by the zoölogists Leuwenhoek, Elsner, Redi, and Fahlberg; even Linnæus assented to this belief and stated that the eel was viviparous. It is but natural that unskilled observers, when they open an eel and find inside of it a greater or smaller number of living creatures with elongated bodies, should be satisfied, without further observation, that these are the young of the eel; it may be distinctly stated, however, that in all cases where eels of this sort have been scientifically investigated, they have been found to be intestinal worms.*

"(III.) The last group of errors includes the various suppositions that eels are born not from eels, but from other fishes, and even from animals which do not belong at all to the class of fishes. Absurd as this supposition, which, in fact, was contradicted by Aristotle, may seem, it is found at the present day among the eel-catchers in many parts of the world.

"On the coast of Germany a fish related to the cod, *Zoarces viviparus*, which brings its young living into the world, owes to this circumstance its name *Allmuter*, or eel mother, and similar names are found on the coast of Scandinavia."

"In the lagoon of Comacchio," continues Jacoby, "I have again convinced myself of the ineradicable belief among the fishermen that the eel is born of other fishes; they point to special differences in color,

* It is very strange that an observer, so careful as Dr. Jacoby, should denounce in this connection the well-known error of Dr. Eberhard, of Rostock, who mistook a species of zoarces for an eel, and described the young, which he found alive within the body of its mother, as the embryo of the eel. In Jacoby's essay, p. 24, he states that the animal described by Eberhard was simply an intestinal worm, an error which will be manifest to all who will take the pains to examine the figure.

and especially in the common mullett, *Mugil cephalus*, as the causes of variations in color and form among eels. It is a very ancient belief, widely prevalent to the present day, that eels pair with water snakes. In Sardinia the fishermen cling to the belief that a certain beetle, the so-called water-beetle, *Dytiscus Roeselii*, is the progenitor of eels, and they therefore call this 'mother of eels.'"

IX.—Search for and discovery of the female eel.

A scientific investigation into the generation of eels could only begin when, at the end of the middle ages, the prohibition which the veneration for Aristotle had thrown over the investigations of learned men was thrown aside. With the revival of the natural sciences in the sixteenth century we find that investigators turned themselves with great zeal to this special question. There are treatises upon the generation of the eel written by the most renowned investigators of that period, such as Rondelet, Salviani, and Aldrovandi. Nevertheless, this, like the following century, was burdened with the memory of the numerous past opinions upon the eel question, and with the supposed finding of young inside the body of the eel.

The principal supporters of the theory that the eel was viviparous, were Albertus Magnus, Leeuwenhoek, Elsner, Redi, and Fahlberg. The naturalists, Franz Redi and Christian Franz Paullini, who lived in the seventeenth century, must be mentioned as the first who were of the opinion, founded, however, upon no special observations, that the generation of the eel was in no respect different from that of other fishes.

In the eighteen century it was for the first time maintained that the female organs of the eel could certainly be recognized. It is interesting that the lake of Comacchio was the starting point for this conclusion as well as for many of the errors which had preceded it. The learned surgeon, Sancassini, of Comacchio, visiting an eel fishery at that place in 1707, found an eel with its belly conspicuously enlarged; he opened it and found an organ resembling an ovary, and, as it appeared to him, ripe eggs. Thereupon he sent his find, properly preserved, to his friend, the celebrated naturalist, Valisneri, professor in the university of Padua, who examined it carefully and finally, to his own great delight, became satisfied that he had found the ovaries of the eel. He prepared an elaborate communication upon the subject, which he sent to the Academy at Bologna.*

At the very beginning there were grave questions raised as to the correctness of this discovery. The principal anatomical authority at Bologna, Professor Valsalva, appears to have shared these doubts, especially since shortly after that a second specimen of eel, which pre-

* I fail to find any record of the publication of this paper, except that given by Jacoby, who states that it was printed at Venice in 1710 with a plate, and subsequently, in 1712, under the title "Di ovario Anguillarum," in the proceedings of the Leopold Academy.

sented the same appearance as that which was described by Vallisneri, was sent from Comacchio to Bologna. The discussion continued, and it soon came to be regarded by the scientific men of Bologna as a matter of extreme importance to find the true ovaries of the eel. Pietro Molinelli offered to the fishermen of Comacchio a valuable reward if they would bring him a gravid eel. In 1752 he received from a fisherman a living eel with its belly much extended, which, when opened in the presence of a friend, he found to be filled with eggs. Unfortunately the joyful hopes which had been excited by this fortunate discovery were bitterly disappointed when it was shown that the eel had been cunningly opened by the fisherman and filled with the eggs of another fish. The eel question came up again with somewhat more satisfactory results when, in the year 1777, another eel was taken at Comacchio which showed the same appearance as the two which had preceded it. This eel was received by Prof. Cajetan Monti, who, being indisposed and unable to carry on the investigation alone, sent a number of his favorite pupils to a council at his house, among whom was the celebrated Camillo Galvani, the discoverer of galvanism. This eel was examined by them all and pronounced to be precisely similar to the one which had been described by Vallisneri seventy years before. It was unanimously decided that this precious specimen should be sent for exhaustive examination to the naturalist Mondini, who applied himself with great zeal to the task, the results of which were published in May, 1777. The paper is entitled "De Anguillæ ovariis," and was published six years later in the transactions of the Bologna Academy.* Mondini was satisfied that the supposed fish which Vallisneri described was nothing but the swimming bladder of the eel in a diseased state, and that the bodies supposed to be eggs were simply postules in this diseased tissue. In connection with this opinion, however, Mondini gave, and illustrated by magnificent plates, a good description and demonstration of the true ovaries of the eel, as found by himself. This work, which in its beautiful plates illustrates also the eggs in a magnified fold of the ovary, must be regarded as classical work, and it is an act of historic justice to state that neither O. F. Müller nor Rathke, but really Carlo Mondini was the first discoverer, describer, and demonstrator of the female organs of the eel, which had been sought for so many centuries.†

*De Bononiensi Scientarum et Arterium Institute atque Academia Commentarii. Tomus VI. Bononiæ, 1783, p. 406, seq.

†Prof. G. B. Ercolani, of Bologna, and also Crivelli and Maggi, in their essays published in 1872, have rightly stated that Mondini's priority of discovery has been overlooked in Germany. Neither Rathke nor Hohnbaum-Hornschech nor Schlüser have mentioned his work. S. Nillson, in his Skandinavisk Fauna, 1855, says nothing of Mondini. He mentioned as the first discoverer of the ovaries O. F. Müller, while Cuvier, in his "Historie Maurelle de Poissons," assigning the honor rather to Rathke. Th. von Siebold is the first to announce in his work, published in 1863, Die Süsswasserfische Von Mitteluropa, page 349, that Mondini, almost contemporaneously with

Three years later, entirely independent of Mondini, the celebrated zoölogist, Otto Friedrich Müller, published his discovery of the ovary of the eel in the "Proceedings of the Society of Naturalists," at Berlin.*

The discovery of Mondini was next specially brought into prominence through Lazzaro Spallanzani. This renowned investigator, in October, 1792, went from Pavia to the lagoons of the Po, near Comacchio, for the sole purpose of there studying the eel question. He remained at Comacchio through the autumn; he was, however, unable to find anything that was new regarding the question, but in the report upon his journey of investigation he entirely threw aside the discovery of Mondini, and announced that the ovaries discovered by this authority were simply fatty folds of the lining of the stomach.†

It was without doubt this absolute negative statement of such a skilled investigator as Spallanzani which for a long time discouraged further investigations on the eel question, and allowed what had already been discovered to be regarded as doubtful, as finally to be forgotten. So when Professor Rathke, of Königsberg, in his assiduous labors upon the reproductive organs of fishes, in the year 1824, described the ovaries of the eel as two cuff and collar shaped organs on both sides of the backbone, and in the year 1838 described them as new, he was everywhere in Germany (and to a large extent to the present day) regarded as the discoverer.† The first picture of the ovary after that of Mondini, and the first microscopical plate of the egg of the eel Hohnbaum-Hornschuch presented in a dissertation published in 1842—a paper which should be rightly considered as of great importance in the literature of this question. The questions concerning the ovaries of the eel may be regarded as having been brought to a distinct conclusion by Rathke, who, in the year 1850, published an article describing a gravid female eel, the first and only gravid specimen which had, up to that time, come into the hands of an investigator.

O. F. Müller, and independently from him, discovered the ovaries of the eel. The error, as was discovered by Italian zoölogists later than by those of Germany, arose from the fact that the announcement of Müller's discovery was printed in 1780, while that of Mondini, which was made in 1777, was first printed in 1783.

*O. F. Miller, Bemühungen, bei den Intestinal Wurmern

† *Rathke,* who first, since Mundini, has in detail described (1824, 1838, and 1850) the ovaries of the eel, is considered by some to have recognized them; but this, however, is not true, the additions made by him to Mundini's description being to a great extent erroneous. It is not true that the transverse leaflets are wanting in the ovaries of the eel, as he asserts in his last work, contrary to his former description, which was probably based on the law of analogy, and that thereby they are distinguished from those of the salmon and sturgeon. It is not true, what Rathke likewise asserts, that the genital opening of the eel consists of two small canals, for I have invariably only found one, which opens in the urethra. Rathke has certainly described the eggs quite exactly, distinguishing the larger whitish ones, having a diameter of about one-fifteenth of a line, and the smaller transparent ones, with the germinal vesicle inside; but Mundini likewise says: "*innumeras sphærulas minimas, æquales, pellucidas, divisas tamen, quæ in centro maculam ostendebant, ecc. vidi,*" thus showing the true nature of the ovaries and the eggs, and contrasting them with the fatty formation and with the ovaries and eggs of other osseous fish." (Syrski.)

X. Hunt for the male eel and its discovery by Syrski.

The history of the search for the female of the eel having been given, for the most part, in a translation of the work of Dr. Jacoby, it seems appropriate to quote the same author concerning the search for the male eel, which, though much shorter, is none the less interesting.

In the dissertation of Hohnbaum-Hornschuch, published in 1842, the opinion was expressed that certain cells found by the author in the ovaries which differed from the egg cells by their form and contents, should be regarded as the spermary cells of the eel, and that the eel should be regarded as hermaphrodite. Six years later Schlüser presented an interesting dissertation upon the sexes of lampreys and eels in which he pronounced these opinions of Hohnbaum-Hornschuch to be erroneous, and expressed the opinion that the male eel must be extremely rare, or that it was different, perhaps, from the female. From this time up to the beginning of 1870 a male eel was never seen, nor do we find any opinions expressed concerning the form of the male of the eel or its reproductive organs.*

According to Robin in 1846, George Louis Duvernoy (Cuvier, Anatomie Comparée, ed. 2, 1848, tome viii, p. 117) described the ruffle-tube type of the testis of the lampreys and eels, with the free margin festooned in lobules, shorter to the right than to the left, like the ovaries, &c. He added: "At the breeding season, we perceive in it an innumerable quantity of granulations, or small spermatic capsules, the rounded form of which has often led to their being confounded with the ovules, at least in the eels, in which, in reality, these capsules are nearly of the same size as the ovules, but the latter are distinguished by their oval form." The ovules are spherical, and not oval; but the other facts are fundamentally correct. It is also in error that Duvernoy adds (p. 133): "The eels and the lampreys have no deferent canal, any more than an oviduct. Like the ova the semen ruptures the capsules in which it has collected and diffuses itself in the abdominal cavity, whence it is expelled in the same way as in the ova."

By some droll coincidence the university of Bologna and, soon after, that of Pavia, were again prominent participants in the eel tournament. At the meeting of the Bologna Academy, December 28, 1871, Prof. G. B. Ercolani read a paper upon the perfect hermaphroditism in the eel.†

Fourteen days later Prof. Balsamo Crivelli and L. Maggi read a detailed and elaborate paper upon the "true organs of generation in

* Robin, Comptes Rendus, 1881, p. 383.

† Jacoby states that in a paper by Rathke, published in 1838 in the *Archiv für naturgeschichte*, he remarked, "I expect soon to be able to say something concerning the male organs of the eel."

It would be very interesting to know whether in the papers left by this skillful investigator there may not have been recorded some valuable observations concerning the male eel.

eels." These investigators, without concerted action, had all at once brought up the celebrated issue of the previous century; this time, however, having specially in view the male organs of the eel, while all were convinced that they had reached a final result by their investigations. The results were certainly very peculiar. In the paper of Ercolani it was claimed that the snake-like folds of fat, which had formerly been noticed near the ovarium, were nothing else than the spermaries of the eel, and that upon the left side of the animal this organ developed into a true testicle, while the one upon the right side shrank up and became functionless. In the work of Crivelli and Maggi, on the other hand, the folds of fat next to the ovary were also considered to be the male organs of the eel, while the one on the right-hand side of the animal was considered without any doubt to be the male reproductive organ. The last-named authorities described the spermatozoa which they had seen in this stripe of fat upon the right side. Since these stripes of fat were universally found in all eels, and always in connection with the former, the investigators could come to no other conclusion than that the eels were complete hermaphrodites.

The male organ of the eel, as described by Ercolani, as also by Crivelli and Maggi, shows how carefully investigations may be expended upon things which are not in the least equivocal, since there was not the slightest trace of structure like that of a spermary. The cells of this body in the lining of the stomach next to the ovary are simply fat cells, with all the characteristic peculiarities, just as they are given in all the manuals of histiology. Professor Rauber, of Leipsic has examined these fat cells carefully, and they have also been investigated in many eels by the writer, Dr. Jacoby. Never has anything but fat cells and blood vessels been found in them. The so-called spermatozoa, described in the work of Maggi and Crivelli, proved to be microscopic fat particles or crystalline bodies, such as are commonly found in fat cells. *

In the meantime, at Trieste, the question concerning the male organs of the eel was making a very important advance. Darwin had already expressed the opinion that among nearly all fishes the female was larger than the male. He states that Dr. Günther had assured him that there was not a single instance among fishes in which the male was naturally larger than the female. This opinion may, perhaps, have induced Dr. Syrski, director of the Museum of National History at Trieste, now professor in the university of Lemberg, when he undertook, at the request of the marine officials of Trieste, the determination of the spawning time of the fish which were caught in that region, and was obliged to take up the eel question, to devote his attention especially to the smaller eels. Dr.

* In a microscopic investigation of fatty tissues it is very easy for the so-called Brownian molecular movements to be mistaken for moving spermatozoa, especially in fishes whose spermatozoa, if not very much magnified, show only the head and appear like little bodies globular in form.

Hermes, in behalf of Dr. Syrski, protests against this idea, stating, on the authority of the latter, that the published opinions of Günther and Darwin were unknown to him prior to the publication of Jacoby's paper. Up to that time every investigator had chosen for investigation the largest and fattest of eels, thinking that the largest and oldest specimens must have the most highly-developed organs of generation. On Novembr e29, 1873, Syrski found in the second specimen which he investigated—an individual 15 inches long, which is now preserved in the museum at Trieste—a completely new organ, which had never before been seen within the eel by any former investigator, although tens of thousands of eels had been zealously studied.* Syrski published his discovery in the April number of the proceedings of the Imperial Academy of Sciences, Vienna, in 1874.† The most important point of the discovery was stated to be that in all the specimens of eels in which the Syrskian organ was found, the well known collar-and-cuff shaped ovary, the female organ of generation, was entirely wanting. It was evident from this that eels were not hermaphrodites. The question now arose, is the newly discovered organ in the eel, in its external form, as well as inner structure, so different from the ovary that it could be considered as a partially developed or peculiarly shrunken ovary? According to all researches which have up to this time been made, there is the highest kind of probability that this newly discovered structure is actually the long sought male organ of generation. The investigator cannot, however, answer this question with complete certainty, since the thing which is most necessary to the solution of this question, namely, the finding and the recognition of the spermatozoa, has not yet been accomplished.

In February, 1879, Professor Packard announced the discovery of spermatozoa in eels from Wood's Holl, Mass., but soon after declared that this was a mistake, and that he had been deceived by molecular movements among the yolk nuclei in the female organs. The discovery of spermatozoa in the spermaries of the conger-eel, recently announced by Dr. Hermes, of Berlin, is, however, sufficient to demonstrate fully the correctness of Syrski's theory. The confirmation in the case of the common eel is solely a matter of time.

XI. How to distinguish male and female eels.

a. Internal characteristics.—Benecke.

The differences between the organs of sex in the eel are well described by Benecke. The ovaries of the eel are two yellowish or reddish-white

*"I commenced my investigations," writes Syrski, "on the 29th November last year (1873), and already in the second eel which I dissected on that day I found the testicles, and therefore a male individual of the eel. I sent in March of the following year (1874) to the Academy of Sciences in Vienna a preliminary communication, which was read at the public session held the 15th April, and printed in the reports of the academy."

†In 1875, Professor Von Siebold found male eels in the Baltic at Wismar, although this discovery was not at that time made known to the public. They have since been found in the German Ocean, in the Atlantic, and in the Mediterranean.

elongate organs as broad as one's finger, situated alongside of the backbone, arranged in numerous transverse folds, extending through the entire length of the abdominal cavity. They have no special opening to the outside of the body, and their contents must be discharged into the abdominal cavity and must find exit through the very small opening situated behind the anus. These two bodies, on account of their great size, are of course not easily overlooked, but they contain such a great quantity of fatty cells and the eggs imbedded in them are so small and delicate that one might easily believe, even after a superficial microscopic examination, that the whole organ consists only of fat. While the eggs of other fishes measure from one to three millimeters in diameter—and sometimes are much larger—still the eggs in the ovary of the eel have, on an average, a diameter of about .1 millemeter, and are so closely surrounded by fatty cells with outlines much more strongly marked that it requires great skill to prepare a microscopic slide in which they shall be as plainly visible as they are in the accompanying illustration, in which they are magnified 150 diameters. When a person has a microscope which magnifies only 100 diameters, it is best to put a portion of the ovary in water when dissecting it, in order that the eggs may be easily found. It is much easier to find the eggs in young eels, 7 or 8 inches in length, than in the adult fish, since in the former, although the ovaries and the eggs are smaller, the fat cells have not made their appearance, and the eggs are, therefore, plainly visible at the first glance through the microscope. The number of eggs is extraordinarily large, amounting to many millions. The eggs of larger size, which sometimes are found in great quantities in eels that have been cut up and have been considered to be eel eggs, have always proved to be the eggs of other fish which they have swallowed, and in the course of cutting them up have been found in the eel's belly.

The male eels, which are found only in the sea and in the brackish water, are much smaller than the females, rarely exceeding 15 or 16 inches in length; in them, in the place of the ovaries in the female, are found spermaries, which differ in appearance in the manner shown in the illustration. These consist of two tubes which stretch the whole length of the body cavity, situated close to each other, and provided with numerous sacculations. Ripe spermatozoa are as rarely found in these organs as eggs ready to be laid have been found in the ovaries of the female. According to many accounts the male eels, which later were found also by Von Siebold in the Baltic Sea at Wismar, differ from the females in the possession of a proportionally sharper snout, less conspicuous dorsal fins, darker colonation of the back, a more prominent and metallic luster upon the sides, the clean white coloration of the belly, and the larger size of the eyes. I propose to reproduce here the original descriptions and figures of Syrski, the discoverer of the male eel.

Having met, writes Syrski, with many errors regarding the female

organs of reproduction in the descriptions hitherto given of them, I intend to commence by describing these organs, first, with the view of rectifying and completing the details, and also for the purpose of comparison with the male organs.

The ovaries of the eel.—These organs (fig. 16), two in number, are ribbon-shaped, with leaflets on their outer face, and with transverse folds. In the natural position of the live fish, the one extends to the left and the other to the right of the alimentary tube, following most of its angles nearly the whole length of the abdominal cavity to the place where the dorsal parietes is confluent with the lateral.

The right ovary commences at a point nearly corresponding to that where on the outside the right pectoral fin ends, and the left ovary commences about two centimeters and ends three to four centimeters behind the former. They extend three to six centimeters back of the anus, into the caudal part of the animal's body; they do not, however, unite in a single body, as some have asserted, but both are toward the end inclosed in a peritoneal membrane, and are separated from each other by the union of these membranes, having each on their inner face an accessory ovary (*pars recurrens ovarii*). In rare cases is such an accessory ovary wanting either on the right or on the left side.

The ovaries in fully-grown eels are in the middle about two centimeters larger, and posteriorly terminate in a thread-like form. They are not smooth on both sides, but have, as was said above, on their outer side numerous transverse folds (fig. 2) full of eggs (fig. 3).

It is another of Rathke's erroneous assertions, likewise maintained by others, that the genital opening through which the eggs pass out from the abdominal cavity is formed by two holes, a right one and a left one. I have invariably found in all specimens examined a simple hole, which communicated with the right and left half of the abdominal cavity by means of a transverse fissure between the straight intestine and the urinary bladder (*fissura recto-vesicalis*) and opens in the urethra (fig. 4).

It is generally admitted that the eggs, when loosened from the ovaries, fall indiscriminately into the abdominal cavity, but it is not said which way they take in order to go out through the genital aperture. As I have invariably found that the fully-developed ovaries lean with their outer surface against the side of the abdominal cavity, and approach with their free edges the lower portion of this side, forming, so to speak, a furrow, I must conclude that the loosened eggs descend between the abdominal partition and the folds and leaflets of the ovary in the above-mentioned furrow, and from it pass to the genital aperture without scattering in the abdominal cavity.

As to the development which the ovaries undergo, I have observed, from the end of November till the beginning of March, in many adult eels, of the length of 530 millimeters and more, that the ovaries were of the breadth of 15 to 25 millimeters, and of a yellowish and sometimes

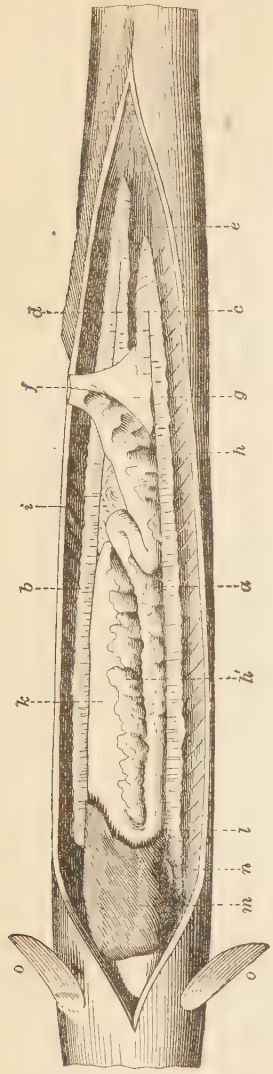


FIG. 1. *Female eel, longitudinal section of the abdomen; natural size.*

a. Right ovary.
b. Left ovary.
c. Accessory part of the right ovary.
d. Left accessory part.
e. Dividing membrane.
f. Anal depression.
g. Urinary bladder.
h. Fat on the right side, erroneously taken for the testicles by some.
h'. Similar fat covering the stomach.
i. Fat on the left side.
k. Stomach.
l. Pylorus.
m. Liver.
n. Gall-bladder.
oo. Pectoral fins.

FIG. 2. *Piece of the ovary, twice its natural size, with ovarian leaflets arranged in transversal rows, on its outer surface.*

The shorter border attached to the dorsal wall of the abdominal cavity; the longer being free.

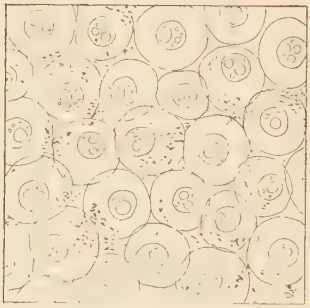


FIG. 3. *Piece of a somewhat developed ovary, one hundred times the natural size, showing the transparent eggs with the germinative vescicles and the germinative dots.*

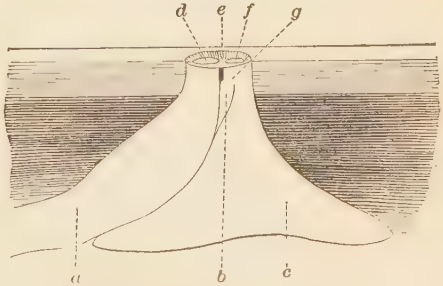


FIG. 4. *Anal part of a female eel, twice the natural size.*

a. Straight intestine.
b. *Fissura recto-vesicalis.*
c. Urinary bladder.
d. Annus.
e. Partition.
f. Uro-genital opening.
g. Outlet of the genital opening in the uretha.

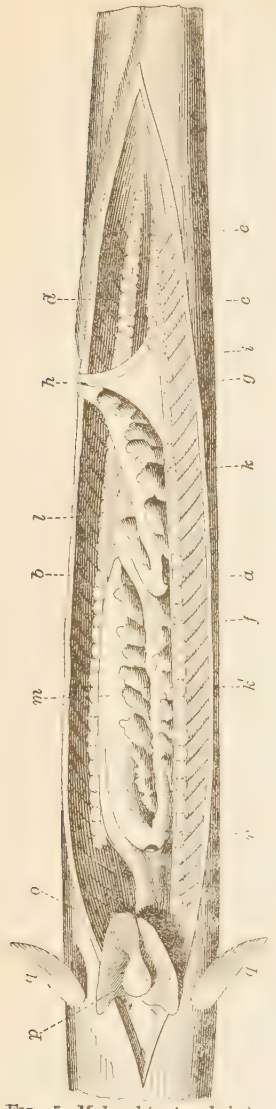


FIG. 5. *Male eel (natural size).* *a.* Right testicle. *b.* Left testicle. *c.* Right accessory part. *d.* Left accessory part. *e.* Dividing membrane. *f.* Deferent canal. *g.* Seminal pouch. *h.* Anal depression. *i.* Urinary bladder, covered to a great extent by the seminal pouch. *k.* Fat on the right side. *k'.* Similar fat covering the stomach. *l.* Fat on the left side. *m.* Stomach. *n.* Pylorus. *o.* Liver, turned up to show the inner surface adhering to the œsophagus and the stomach. *p.* Gall-bladder. *qq.* Pectoral fins.

reddish-white color, produced by the development of adipose tissues and of the blood-vessels, and not by the eggs filled with little globules of fat; the genital aperture and the *fissura recto-vesicalis* were open.

In other eels of a length sometimes of 600 millimeters and more, I found the ovaries less broad, with but little fat, and of a mucous and almost glassy appearance, so that I could discern the so-called vesicles and germinative dots (*nuclei* and *nucleoli*); the genital aperture and the *fissura recto-vesicalis* were closed.

The ovaries of young eels, of the length of about 500 millimeters, contained invariably but little fat, and the eggs were without globules. The gradual growth and enlargement of the ovaries go on simultaneously with the opening of the genital orifice. According to the quantity of fat contained in the ovaries, they have a mucous and glassy, or more or less opaque or white, appearance, or have small shining white dots. From the end of March till October, I found in the majority of eels which I examined, measuring 600 to 700 millimeters in length, that the ovaries were scarcely white, and that the genital aperture was closed. The number of eggs contained in both developed ovaries reaches, according to my calculation, five millions. The larger eggs measured by me had a diameter of one-fourth to one fifth millimeter, while the eggs of an adult "grongo" (*Conger*) had, according to my measurements, a diameter of one-third of a millemeter, and those of the "murena" (*Muræna helena*) almost one millimeter, which explains to me why the ovaries of the two last-mentioned species of fish have long since become known.

In an eel measuring 590 millimeters, examined on the 6th July, the left ovary was entirely wanting, and replaced by a mass of fat.

The spermatic organs.—The position of these organs (fig. 5), which are not ribbon-shaped like the ovaries, but represent two longitudinal rows each with about fifty lobules (fig. 6) of the width at most of three millimeters, and found only in eels not more than 430 millimeters long, corresponds entirely with that

of the ovaries. In these organs are likewise found, toward the posterior end, the spermatic organs (*partes recurrentes*), which, however, as is the case with the ovaries, are sometimes wanting.

The spermatic organs can be distinguished at the first glance from the ovaries of the adult eels and those of the young eels, not only by their lobular form, but also by their shining glassy appearance, by the surface of the individual lobes, which is smooth and without leaflets, and by the much greater density of the tissue, so that with a pair of pincers one can take off a large portion of the organ, which could not possibly be done with a more developed ovary whose tissue is as tender as a cob-web, and is composed of small vessels formed of a thin membrane and filled with eggs and fat.

The fibrous tissue of the spermatic organs is composed of vascular compartments with thicker partitions, inclosing, according to the development of the organ, granular globules (fig. 7).

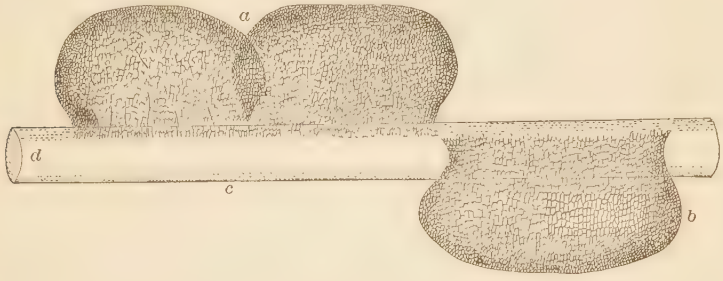


FIG. 6. *Three lobes of the right testicle, with the deferent canal (enlarged ten times.)*
a. Lobes, seen from their outer surface.
b. Lobe, seen from its inner surface.
c. Deferent canal.
d. Anterior part of the same.

These compartments are joined toward the inside and the base of the lobes, which are united to a tube (*vas deferens*), which, cæcal at the commencement, runs along the entire length of the abdominal cavity, and opens near the straight intestine (*rectum*) in a triangular pouch, which likewise contains a *vas deferens* starting from the caudal part of the spermatic organ. This pouch has its outlet in the general orifice, which opens in the urethra (fig. 8).

As regards the development of the spermatic organs, I have observed that the lobes of these organs in young eels, measuring not more than 200 to 300 millimeters in length, are not yet very distinct, forming two thin ribbons differing but little from ovaries of the female in their average size. In eels measuring about 400 millimeters in length, the testicles can easily be distinguished from the ovaries. The former, much straighter, and with tissue, as has been already remarked, much more solid, are provided with a much more developed net-work of vessels; their lobes are very distinct and the deferent canals are usually open, while the ovaries present the appearance of two continuous ribbons,

have a more delicate tissue, and an almost mucous appearance, and contain the eggs with the germinative vesicles.

The deferent canals and the genital orifice are closed in young eels of the male sex, and open simultaneously with the development of the lobes.

In the male eels examined by me from March to October, I have found individuals of 400 millimeters and more in length, whose genital orifice and deferent canals were invariably open, while in some of the smaller ones they were closed and in others open.

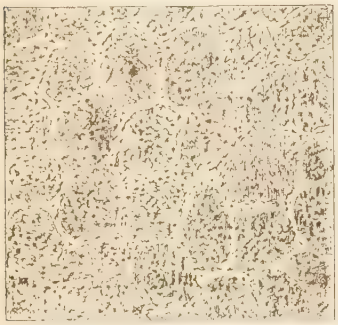


FIG. 7. *Piece of the testicle (one hundred and sixty times enlarged), showing the vascular tissue and the small granules.*

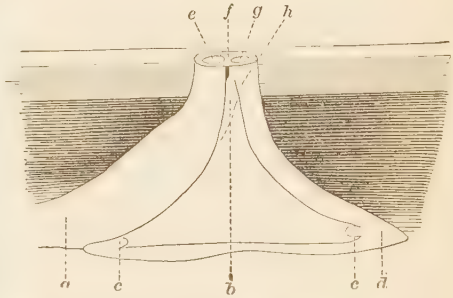


FIG. 8. *Anal part of the male eel, enlarged twice.*
a. Straight intestine.
b. *Fissura recto-vesicalis*, covered by the outside wall of the seminal pouch.
cc. Outlet of the anterior and posterior part of the deferent canal in the pouch.
d. Urinary bladder.

Of the 258 eels examined by me, the males and females were in about even proportion; the greatest length of the former was about 430 millimeters, while the latter were of all sizes up to 1,050 millimeters, which shows that the males are smaller than the females.

b. EXTERNAL CHARACTERISTICS.—JACOBY.

The external differences presented by living eels (remarks Jacoby), corresponding to the presence of an ovary and the supposed male organ, are very interesting.

The most important, writes Jacoby, is (1) the difference in the size and length of the animal. Syrski states that the largest eels found by him with the supposed male organ measured about 17 inches, 430^{mm}. I have, however, found specimens with this organ at Trieste and in Comacchio which measured 17 to 19 inches, 450 to 480^{mm}. All the eels which exceeded this size, for instance those which were over 3 feet in length, 1^{m}, many of them growing to the thickness of the arm of a strong man, have been hitherto found to be females. The other recognizable external character in the female are (2) a much broader tip of the snout in comparison with the small, either attenuated or short and sharply pointed, snout of the eel with the supposed male organ; also (3) a clearer coloration in the female, usually of a greenish hue on the back, and yellowish or yellow upon the belly, while the others have a deep darkish

green, or often a very deep black upon the back and always a more perceptible metallic luster upon the sides (I, once in a while, found eels covered all over with a brownish tint, always possessing the organ of Syrski), usually exhibiting also a white color upon the belly. In addition (4) there is an important external character in the height of the dorsal fin; all females have these fins much higher and broader than the eels of the same size which possess the supposed male organ. Finally (5) there is a character, which is not always a safe one, in the greater diameter of the eye in the eels with the supposed male organ. Eels with quite small eyes are almost always found to be females; eels with the organ of Syrski usually have comparatively large eyes, yet female eels with quite large eyes are not unusual.

The following proportional measurements, the average results of the study of a great number of eels measured by me, will be of general interest; column *a* gives the total length of the eel; *b* the breadth of the snout between the nostrils; *c* the breadth of the snout between the eyes; *d* the length of the snout from the center of the eye to its tip; *e* the average measurement of the eyes; *f* the length of the head to the gill-opening; *g* the height of the dorsal fins, all the measurements being given in millimeters.

	A. Eels with supposed male organ.							B. Female eels.							
	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*a.*	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	
I	480	6	13.5	15	8	52	5	480	8.5	12	17	5	62	9	I
II	470	6	10.5	12	7	54	6	475	7.5	14.5	16	8	59	9.5	II
III	445	5	11	12	6	47	6	440	8	12	14	5	56	7.5	III
IV	411	4	9	12	5.5	47	6	410	8	12.5	13	7.5	51	7	VI
V	386	4.5	9	12	5.5	46	4	378	7.5	11	12	5	49	7.5	V
VI	370	3.5	7	10.5	5	40	6	369	7.5	11	13	6.5	51.5	7	VI
VII	344	4	7.5	10	4.5	40	5	342	6	8	11	4.5	44	6.5	VII
VIII	319	4	7	10	5	40	4.5	313	5.5	8	10.5	3.5	41	6	VIII

According to the distinguishing marks which have been given, special reference having been paid to the height and narrowness of the dorsal fin, much success has been met with in picking out, in the fish-market of Trieste, the eels which possessed the organ of Syrski; absolute certainty in recognizing them cannot, however, be guaranteed. If one is searching among living eels with no characters in mind with the exception of the first—that of length—he will find in every ten eels, on an average, eight females, and two with the supposed male organ; but, if the selection is made with a careful reference to all these marks of difference, the proportion changes, and out of every ten examples about eight will be found with the supposed male organ.

For another excellent discussion with figures of the characters of male and female eels, the reader is referred to a translation of an article by S. Th. Cattie, in the Proceedings of the U. S. National Museum, vol. iii, pp. 280–4.

XII. QUESTION AS TO THE VIVIPAROUS NATURE OF EELS.—BENECKE.

The discovery of the two sexes has not, however, writes Benecke, settled the question whether the eel lays eggs or brings its young alive into the world. There has always been a strong disposition to adopt the latter hypothesis, and there are many people at the present day who claim to have been present at the birth of young eels, or to have found a quantity of young eels in adult eels which have been cut open. Frequently ichthyologists hear accounts of occurrences of this kind, and receive specimens of supposed little eels from one to two inches in length, which have been kept alive for several days in a glass of water. These are usually thread worms, *Ascaris libeata*, which live by the hundred in the intestinal cavity of the eel, and which may be easily distinguished from the eels of the same size by the sharp ends of the body, the absence of fins, of eyes and mouth, and by the sluggishness of their motions. The smallest eels, less than an inch in length, have already the complete form of the adult, and are also transparent, so that with a magnifying glass one may perceive the pulsations of the heart, and see behind it the brownish-red liver; the mouth, the pectoral, dorsal, anal, and caudal fins are easily seen, and the black eyes cannot be overlooked. In addition to the intestinal worms, the young of a fish of another family, *Zoarces viviparus*, have given opportunity to the ignorant for many discoveries; for instance, Dr. Eberhard, in No. 4 of the "Gartenlaube" for 1874, described and illustrated an "embryo of the eel," which, in company with about a thousand similar embryos, had been cut out of the belly of an eel. This tolerably good drawing at first sight is seen to represent the embryo of zoarces which is almost ready for birth, since it still possesses a very minute umbilical sac. It is very evident that the minute egg of the eel could hardly produce a great embryo with an umbilical sac which exceeds by more than a hundred times in size the whole egg. It is also evident that the imagination of the writer had exaggerated the 200 or 300 young in the Zoarces to a thousand.

XIII. HUNT FOR YOUNG EELS.—JACOBY.

As might have been foreseen, remarks Jacoby, Syrski's discovery drew attention anew to the solution of the eel problem. In the spring and summer of 1877, the German and Austrian papers and journals were full of articles and paragraphs upon this subject. Among others the following announcement made the rounds of the press: "Hitherto, in spite of all efforts, science has not succeeded in discovering the secret of the reproduction of the eel. The German Fischerei-Verein in Berlin offers a premium of 50 marks to the person who shall first find a gravid eel which shall be sufficiently developed to enable Professor Virchow in Berlin to dissipate the doubts concerning the propagation of the eel. Herr Dallmer, of Schleswig, inspector of fisheries in that province, offered to transmit communications to Berlin, and in 1878, in the January number of the German Fishery Gazette, he published a detailed and very in-

teresting report of his proceedings. He wrote, among other things, that it was quite beyond his expectation that this announcement would have found its way into nearly all the German journals between the Rhine and the Weichsel, and from the Alps to the sea. The number of letters which he received first rejoiced him, then surprised him, finally terrified him, so that at last he was obliged to refuse to attend to the communications. He had learned at Berlin that an equal number of communications from all parts of Germany had been received, sent directly to the address of Professor Virchow. Objects which professed to be young eels cut out of the parents, but which were really thread worms, were sent to him by dozens; the most incredible stories, usually from women, about great thick eggs which they had found in eels, were received by him. A witty Berliner communicated to him in a packet sent by express the information that the eel problem was now happily solved since a lady eel in Berlin had given birth to twins. Finally Herr Dallmer found himself compelled to insert the following notice in the Schleswiger Nachrichten: 'Since the German Fischerei-Verein has offered a premium for the first gravid eel, the desire to obtain the prize, curiosity, or the desire for knowledge has created so lively an interest upon this point that it might almost be called a revolution. I at one time offered, when necessary, to serve as an agent for communications, but since business has compelled me to be absent from home a great part of the time, I would urgently request that hereafter packages should be sent direct to Professor Virchow in Berlin. I feel myself obliged to inform the public upon certain special points. The premium is offered for a gravid eel, not for the contents of such an eel, since if only these were sent it would be uncertain whether they were actually taken from an eel. The eel must always be sent alone; the majority of senders have hitherto sent me only the intestines or the supposed young of the eel, which were generally intestinal worms; the eel itself they have eaten; nevertheless the prize of 50 marks has been expected by nearly all senders, &c. By this transfer of the responsibilities, the inspector of fisheries has rendered a very unthankful service to Professor Virchow; he was obliged to publish a notice in the papers in which he urgently stated that he wished to be excused from receiving any more packages, for he would hardly know what to do with them. The comic papers of Berlin now circulated the suggestion that hereafter the eel should be sent to the investigators only in a smoked state. This amusing episode is interesting in showing how remarkable an interest the whole world was beginning to take in the eel problem."*

XIV. Undoubted normal reproductive habits of the eel.—Benecke.

It may be assumed with the greatest safety (writes Benecke) that the eel lays its eggs like most other fish, and that, like the lamprey, it only

*Zoologischer Anzeiger No. 26, p. 193; American Naturalist, vol. 13, p. 125, and Jacoby, p. 44.

spawns once and then dies. All the eggs of a female eel show the same degree of maturity, while in the fish which spawn every year, besides the large eggs which are ready to be deposited at the next spawning period, there exist very many of much smaller size, which are destined to mature hereafter, and to be deposited in other years. It is very hard to understand how young eels could find room in the body of their mother if they were retained until they had gained any considerable size. The eel embryo can live and grow for a very long time supported by the little yolk, but when this is gone it can only obtain food outside of the body of its mother. The following circumstances lead us to believe that the spawning of the eel takes place only in the sea: (I) that the male eel is found only in the sea or brackish water, while female eels yearly undertake a pilgrimage from the inland waters to the sea, a circumstance which has been known since the time of Aristotle, and upon the knowledge of which the principal capture of eels by the use of fixed apparatus is dependent; (II) that the young eels with the greatest regularity ascend from the sea into the rivers and lakes.

All statements in opposition to this theory are untenable, since the young eels never find their way into land-locked ponds in the course of their wanderings, while eels planted in such isolated bodies of water thrive and grow rapidly but never increase in numbers. Another still more convincing argument is the fact that in lakes which formerly contained many eels, but which, by the erection of impassable weirs, have been cut off from the sea, the supply of eels has diminished, and after a time only scattering individuals, old and of great size are taken in them. An instance of this sort occurred in Lake Müskendorf, in West Prussia. If an instance of the reproduction of the eel in fresh water could be found, such occurrences as these would be quite inexplicable.

In the upper stretches of long rivers, the migration of the eels begins in April or May, in their lower stretches and shorter streams, later in the season. In all running waters the eel fishery depends upon the downward migrations; the eels press up the streams with occasional halts, remaining here and there for short periods, but always make their way above. They appear to make the most progress during dark nights when the water is troubled and stormy, for at this time they are captured in the greatest numbers. It is probable that after the eels have once returned to the sea, and there deposit their spawn, they never can return into fresh water but remain there to die. A great migration of grown eels in spring or summer has never been reported, and it appears certain that all the female eels which have once found their way to the sea are lost to the fisherman. In No. 8 of the German Fischerei Zeitung for 1878, Dr. Schock published certain statements sent to him by Dr. Jacoby. It is remarked in this paper, among other things, that after the deposition of the spawn, the female eel dies a physiological death, and that occasionally the sea in the neighborhood of the mouths of rivers has been found covered with dead eels whose ovaries were empty. When, where, and by whom this observation was made,

and who pronounced upon the empty ovaries in these dead fish is unfortunately not mentioned.

A great number of the eels remain in inland waters while others proceed to the sea, either because their eggs are at this time not sufficiently ripe, or perhaps because they are sterile. It would seem probable that the increase in the size of the eggs in the wandering eels begins to be very rapid after August and September, while in the earlier months of the year, in all eels of moderate size, the eggs were at the utmost but about 0.09 in diameter. In September of the same year, I found (as an average of numerous measurements) a diameter of 0.10; in October, 0.16; in November, 0.18 to 0.23, while the eggs showed other characters connected with approaching maturity which earlier in the season were not to be seen. All the eels which were captured later—in December and in January—part of which came from rivers and harbors, part from the harbor of Putzig (Putziger Wiek) had eggs measuring from 0.09 to 0.09^{mm}, while, very exceptionally, some measured 0.16^{mm}, although among the fish examined were some which measured 3 feet in length.

XV DO MALE EELS LEAVE THE SEA AND ENTER FRESH WATER.

This problem is one of great interest, both to the biologist and the fish culturist; it is, in fact, the one disputed point still remaining to be solved. Upon its solution appears to depend the final decision of the question, still so warmly debated both in Europe and America, "Do eels breed in fresh water only, in salt water only, or in both fresh and salt water?" As has already been stated, the theory for a long time generally accepted is that the eels are "catadromous," descending to the sea to spawn. This theory is, however, sharply contested by many observers, chief among whom on this side of the Atlantic is the Hon. Robert B. Roosevelt, President of the American Fish Culture Association. It appears probable to the writer that the truth lies somewhere between these two extremes, and that it will be hereafter ascertained that the eel, like a majority of other animals, has flexible habits, sometimes deviating from its ordinary custom, which appears to be to spawn in salt or brackish water.

Male eels have been found in the following localities:

(1.) In 1874, by Syrski, in the fish markets of Trieste, these markets being supplied with eels from Chroggia on the Adriatic, and to a lesser extent from the lagoons of Comacchio.

(2.) In 1875, on the coasts of France, by Dareste.

(3.) In 1875, among specimens of *Anguilla marmorata* from India.

(4.) In 1875, in the Baltic, at Wismar on the Danish coast, by Prof. Von Siebold.

(5.) In 1877, in the lagoons of Comacchio, by Jacoby. Among 1200 specimens, five per cent. were males; while among those less than 15 inches in length 20 per cent were males. This was in brackish water. (See paragraph XIX).

(6.) In 1879, at Trieste, by Dr. Hermes, who found 15 males among 20 eels selected by Dr. Syrski.

(7.) In 1880, on the Baltic coasts of Denmark, by Dr. Hermes. Out of one lot of 36 from Wismar, he obtained 8 males, thus repeating Van Siebold's observation.

(8.) In 1880, from the Baltic between Zealand and Saland, Denmark. Out of one lot of 36, Dr. Hermes obtained 8 males.

(9.) In 1880, in France, by Robin.

(10.) In 1880, by Cattie.

(11.) In 1880, by Dr. Hermes, at Cumlosen, on the Elbe, about 120 miles from the German Ocean.

(12.) In 1880, at Rügers on the Baltic, by Dr. Hermes, who found 44½ per cent. males in one lot of 137.

(13.) By Dr. Pauly, among eels planted at Hünnigen, in Elsass.-Lothringen. See below.

It has been shown by Dr. Pauly that among the very young eels [montée] taken near the mouths of rivers is a considerable percentage of males, which, when transplanted to fresh water, will there retain their masculine characters and develop into perfect adult males. This discovery is, of course, of the utmost importance to fish culturists making the attempt to introduce eels into new waters. Its importance has already been pointed out by Director Haack.

The practical lesson to be learned is simply this—that young eels, for introduction into strange waters, must be taken from very near the mouths of rivers, in order that both males and females may be secured. The interest to zoologists lies in the fact that Pauly's discovery renders the theory of Van Siebold less plausible, indicating that the sexes of the young eels are differentiated before they begin to mount the rivers and that the males do not ascend beyond the limits of brackish water.

Dr. Pauly's discovery is so interesting that I propose to translate his own account of it. The investigation was made, I believe, in Munich, and the report from which I quote was published in the Austro-Hungarian Fishery Gazette, of Vienna, December 23, 1880. Dr. Pauly writes: "During the past year I have received from Court-fisherman Kuffer a large number of eels, which I have used in my investigations. The large individuals, all of which came from the lakes of northern Italy, were females. I received, however, from the same individual, another lot of eels, consisting of much smaller individuals, weighing from 20 to 90 grams (⅔ of an ounce to 3 ounces), also taken in fresh water. At the request of Professor Von Siebold, I had paid particular attention to the sexes of the eels which I was engaged in investigating, and to my great astonishment I found that a large majority of these small eels (19 out of 27) were males, possessing, instead of the familiar ovaries, the "lappenorgan" described by Dr. Syrski. A histological

examination of these organs convinced me that the structure of these tissues agreed with that described by Freud.

* * * * * * *

My next inquiry was very naturally concerning the locality whence these eels had been obtained. I learned that Kuffer had received them two years before from Director Haack at Hüningen, and upon questioning Director Haack learned that they had been brought from a French river, the *sèvre niortaise*, where they were caught as young fry [montée] at a distance of ten or twelve miles from its mouth, and furthermore were at the time of examination about four years old. The small size of these fish, their age being taken into consideration, satisfied me that they had been reared in captivity, since uncultivated eels would have been much heavier. The females in this lot of eels exceeded the males in length and weight and also exhibited those external characters described by Jacoby as indicating sex.

The locality in the *sèvre niortaise* where these fish were taken may easily, especially at flood tide, have been within the limits of brackish water; my observations do not prove, therefore, that male eels enter fresh water.

Dr. Jacoby found male eels in the lagoons of Comacchio, where the water is brackish. These males must have ascended in the "mounting" as fry, and probably at the approach of sexual maturity descend with the females to the sea. My investigations and those of Jacoby prove only this: that the young female eels do not necessarily break away from their parents and from their birth-places at sea, and entirely alone proceed upon their migrations, while the males scatter through the sea, but that their brothers seem to accompany them part of the way upon their journey. But how far? Do the males know where pure fresh water begins, and are the fry of different sexes found mingled together only at the river mouths? If we bear in mind the fact that the male organs had so long escaped discovery, that, on account of their crystal-like transparency, their detection in a fresh eel is so difficult, etc., may we not admit that past conclusions are probably erroneous, and that although thousands of fresh-water eels have been studied by different investigators, male eels may yet be found in our streams, especially when more of the smaller individuals have been examined."

* * * * * * * * * *

Dr. Pauly then discusses the observations of Dr. Hermes, who found 11 per cent. of males among eels taken at Willenberg, on the Elbe, about 120 miles from the German Ocean, and no males whatever at Havelberg, 20 or 30 miles higher up the stream, and closes his essay with the following conclusions: "*Male eels undoubtedly ascend the rivers, but the numerical percentage of males to females appears to diminish as one proceeds up the streams.*" This fact is opposed to the theory proposed by some one that young eels are at first of undifferentiated sex and have the tendency under the influence of fresh water to become females, under that of salt water to develop male characters."

XVI. STRANGE MISSTATEMENTS IN ICHTHYOLOGICAL LITERATURE.

One may conclude from these observations that the eels preparing to spawn leave the inner waters early in December and seek out the deeper places of the sea, where they cannot be caught with our ordinary implements of capture. The eel eggs can only be found by a systematic investigation of certain parts of the sea bottom with the dredge and the microscope. This investigation might also include the sinking of the migrating eels in special cases to the bottom of the sea, in order to determine whether, under these circumstances, the eggs would ripen more rapidly. By using the largest fish for this purpose one could arrange, by means of small openings in the cages, to permit the entrance of the small male eels. At any rate, there is no doubt from these observations that the spawning period of the eel takes place in winter.

In an article by Guido Lindenhain, entitled "The Natural History of the Eel" (*Zur Naturgeschichte der Aale*), which has recently been published in the Austro-Hungarian Fishery Gazette, extending through six numbers, a fanciful contributor of that paper, among other wonderful things, claims to have discovered the spawning of the eel in rivers and ponds. I will allow the very sagacious gentleman to recount his summer-night's dream in his own words, in order to show with what certainty and precision the most baseless fables concerning the natural history of the eel are even yet narrated:

"The methods of spawning by the eel," writes this keen observer, "are very interesting, but to observe them is very difficult and tiresome, and, indeed, only possible when the spawning places have already been determined by experience. One must remain for many nights upon the shore, hidden behind the bushes, with unflagging attention, until these nocturnal adventurers have come into the shallow water and made their presence known by their snake-like motions at the surface. As soon as they have gathered together upon their chosen haunts there is a great commotion in the water, and powerful blows are heard, so that the water splashes up a considerable distance, and the surface is covered with little waves, as if some great object were moving about, after which one gets glimpses of parts of the bodies of the contending rivals of the happy spawning fishes themselves. After the duration of an hour or so it is again quiet, and one sees that the water is moved in different directions in serpent-like waves, which become less and less apparent to the eye of the observer, while the eels are leaving the spawning-places and are betaking themselves to hunt for food or are seeking their customary quiet dwelling-places. If the observer, moved by overwhelming curiosity, comes on the following day to the same place, he sees nothing, but if he looks with a strong magnifying-glass carefully over the water-plants, he discovers little greenish-white eggs resting upon the bottom, out of which the young eels will escape in about six weeks."

"It is only to be regretted that the enterprising observer has not illustrated the whole development of the egg by photographic views of his fancies."

Another wonderful story was narrated by Dallmer.*

A Flensburg eel-smoker told him that once, in April, one of the sacks in which eels had been sent to him, after it had been emptied, was put into the water with the others; after having been tied up he found, after eight to fourteen days, millions of living young eels from one to two inches long. He thought that fertilized spawn had been left in the bag which, in eight to fourteen days, had developed into fishes of one to two inches in length. A million of young eels of $1\frac{1}{2}$ inches in length would take a space of 9,761 cubic inches, which would be much more than a sack could contain. Such a quantity of little fishes would scarcely be able to find in a sack tied together at its mouth food enough to enable them to grow from a very minute size (the eggs in the ovary have been found only 0.23^{mm} large, and may, perhaps, when laid, measure 0.5^{mm}) in eight days to a length of from one to two inches; let us, however, suppose that the eel-smoker had confounded a hundred little eels with as many millions, it could hardly, even then, happen that these little animals in from eight to fourteen days could have grown to 160 times their original dimensions. The story would be much more probable if it were supposed that the young eels in their wanderings toward the fresh waters had, perhaps, found their way into a bag which was not tied up at its mouth.

In De La Blanchère's "Nouveau Dictionaire general de peche, Paris, 1868," occurs the following paragraph, without any indication of its source: "Chenu and Desmarest do not hesitate to state that the eel spawns upon the mud after a kind of copulation; that the eggs remain, adhering together, joined by a glutinous substance analogous to that which connects the eggs of the fresh-water perch, and forms little pellets or rounded globules. Each female, as they have succeeded in observing, produces annually many of these masses. The little fish soon hatch out and remain, for the first few days after their birth, together in these masses, but when they have reached a length of 4 or 5^{mm} they shake off the bonds which hold them and soon ascend in great bodies the streams and brooklets near which they find themselves."

According to this, the eggs are deposited in masses of slime, inside of which the young hatch out in the course of a few days, and a few days later they shake themselves free and swim about at liberty.

When and where these investigators have made such observations is not to be found out from the "Dictionaire"; at any rate, it is very hard to understand how they have proved that the same female eel yearly lays several sets of eggs.

XVII. Benecke on the movements of young eels.

Benecke gives the following thorough discussion of the movements of young eels:

The young eels, hatched out of the eggs at sea, doubtless live at the

* Fische und Fischerei im Sussen Wasser, Segeberg, 1877.

bottom until they grow, through consumption of rich food substances there to be found, to a size from 1 to 3 centimeters. When they have attained this size they begin their wanderings in immense schools, proceeding to ascend into the rivers and lakes. These wanderings of the young eels have been known for a very long time; for instance, in the lagoons of Comacchio, in which they may be found, for the most part, after they have gained the length of from 6 to 8 millimeters, and in France, later also in England, Denmark, Sweden, and, more recently, in Germany they have also been observed.

According to the French reports young eels are hatched out early in the winter, and in February, having attained the length of 4 or 5 centimeters, they appear in the brackish water at the mouth of the Loire in immense numbers, soon to begin their wanderings up the stream. They swim in crowded schools at the surface of the river right up to the banks, and little detachments of the army deploy at the mouth of each tributary and pursue their wanderings along its course. These swarms of young eels are called in France "Montèe," in Italy, "Montata." The number of the young fish is, as might be expected from the number of the eggs in the ovary of the eel, wonderfully large. Redi has recounted that from the end of January to the end of April the young fish continue wandering up the Arno, and that in 1867 over 3,000,000 pounds of them were taken in five hours. Into the lagoons of the Comacchio the eels pour from February to April. In March and April they have been noticed in many French rivers, in which the migration continues for from eight to fourteen days. The first account of these wanderings in Germany was that given by Von Ehlers. In 1863 he wrote to Von Siebold: "This took place about ten years ago, in the village of Drennhausen, in the Province of Wesen, in the Kingdom of Hanover. As we were walking, towards the end of June or the beginning of July, on a dike, which at that place projects out into the Elbe, we noticed that along the entire shore there might be seen a moving band of a dark color. Since everything which takes place in the Elbe is of interest to the inhabitants of that region, this phenomenon immediately attracted attention, and it soon became apparent that this dark band was composed of an innumerable body of young eels, which were pressing against each other, as, at the surface of the stream, they were forcing their way upwards towards its source, while they kept themselves so close to the shore that they followed all its bendings and curves. The width of this band of fish at the place where it was observed (where the Elbe has a considerable depth) was perhaps a foot, but how deep it was could not be observed, so thickly crowded together were the young eels. As they swam a great number could be taken in a bucket, and it was very annoying to the people who lived along the Elbe that so long as the procession of fish lasted no water could be taken out of the river which was not full of the little fish. The length of the young eels was, on an average, from 3 to 4 inches; the thickness of the body was about equal to that of a goose-quill. By

themselves might here and there be seen swimming eels of greater size, but none of them were probably more than 8 inches in length. All of them, even the smallest, were dark colored. This wonderful procession of fishes continued unbroken and of the same density throughout the whole of the day on which it was first observed, and continued also upon the following day. On the morning of the third day, however, not one of the young eels was to be seen."

Similar observations have been made at Wittenberg, on the Elbe. Kuppfer observed great quantities of young eels, of about 3 centimeters in length, in the brackish water of the Eider, at Freiderickstadt; so also did Von Stemann.

"Every year," writes the latter, "from April to the end of June, there appear great masses of young eels, which are present in large schools toward the Upper Eider, seeking in every way to pass each other. In April the first eels show themselves generally singly; cold weather has evidently kept them back up to this time; since this year, until to-day, no ascent whatever has taken place, and now the approach of the great schools is beginning. Where the current is feeble, the procession is broad; but where the eels encounter a strong current—near a mill—it becomes small, and presses close to the shore, in order to overcome the currents. The little animals swim eagerly and rapidly along near the banks until they find a place over which they decide to climb. Here they lie in great heaps, and appear to await the rising of the tide, which makes their ascent easier. The tide having risen, the whole mass begins to separate without delay; eel after eel climbs up on the steep wall of rock, determined to reach the little pools, at the height of 15 or 20 inches, into which some of the water from the Upper Eider has found its way. Into these holes the little animals creep, and have yet to travel a distance of 40 or 50 feet under the roadway before they can reach the Upper Eider. Another detachment betakes itself to the sluice-ways, and clings to the cracks in the wood; also around the mills their ascent may be observed, especially about sunrise."*

Davy sends a similar account from Ireland. He was a witness of the ascent of young eels, or "elvas," at Ballyshannon, at the end of July, 1823; he speaks of the mouth of the river under the fall being "blackened by millions of little eels about as long as a finger, which were constantly urging their way up the moist rock beside of the fall." "Thousands," he adds, "died; but their bodies, remaining, served as a ladder by which the rest could make their way; and I saw some ascending even perpendicular stones, making their way through wet moss or adhering to some eels that had died in the attempt."*

*Professor Benecke had in his possession some of the young eels, which escaped from all the vessels in which they were confined, and even climbed to the ceiling of his room.

*Eel-fairs in Connecticut.—Fresh-water eels may be caught in large numbers, in weirs along the lake streams, when descending at the fall equinox to deposit their spawn in some lower region, and in the following August their offspring, from three

Such is the energy of these little animals that they continued to find their way in immense numbers to Loch Erne.

In the little eels which ascend the rivers there are no traces of sexual organs, but in the fresh water they develop only into females. One of the most recent observations made by Dr. Pauly, in Munich, would appear to contradict this idea, since he discovered male eels among the fish which were brought with a lot of young eels to Hüningen, were kept there for two years in ponds, and were finally released in the fish pond of Court-Fisherman Kauffer. We should bear in mind, however, that these young eels were captured at the mouths of fresh rivers in brackish water; and that among the numerous small eels which swim in the brackish water there must be many larger specimens, in which the male organs have already begun to develop. Such are doubtless those which were sent in the male condition to Hüningen and Munich, and were there recognized as males. This presumption can be set aside only if male eels shall hereafter be found among the fish which are caught in the upper part of rivers in the condition of young fry.

Concerning another important fact which is connected with the movements of the young fry of the eel, I became acquainted last year (in the course of an exploration of the waters of the district of Konitzkunde) with the river Brahe, at Mühlhof, above Rittel, where a high dam was built in 1846 and 1847 for the purpose of watering a large system of meadows by the overflowing of the stream. Below the dam is an inclined plane (constructed of boards), about 300 feet long, built for the purpose of preventing the water, which rushes out when the sluice-gate is opened, from washing away the bottom of the stream and its banks. This plank floor consists of two layers, the lower one of 2-inch, the upper one of 3-inch boards. The grade of the dam at Mühlhof (33 feet 3 inches) has entirely cut off the ascent of the fry of the eel into the upper part of the Brahe and the lakes tributary to it, and the number of eels caught above the dam—which was formerly very considerable—has become reduced almost to nothing. In the year 1847 the construction of the dam and the inclined plane was completed; in 1852 the upper layer of the planks on the plane had warped and sprung up in many places, so that it had to be torn up for repairs. The cause of the warping was immediately discovered: thousands of eels—as thick as a man's finger—somewhat flattened in shape, and, on account of the absence of light, of a pure white color, filled the space between the two layers of planks, and their united pressure from beneath had caused the upper

to six inches long, return in immense numbers. The basin of the Still River Falls, near Colebrooke line, is for several days alive with them. They may be seen laboriously crawling up every rock which is moistened by the spray of the fall, and endeavoring to reach their ancestral lake or dam. At the foot of the Niagara Falls this phenomenon may be witnessed on a large scale at the same season of the year or later, and probably in other places where the fall is too high and the current too swift for the young eels to stem it without contact with the rocks.—Annals of Winchester, Conn., Boyd, p. 26.

layer to yield; these eels had found their way between the boards as fry, where they had found sufficient food and had grown to such a size that the pressure of their united strength had pushed up the roof of their prison. These facts, observed by an old millwright, were communicated to me by Privy Counsellor Schmid, of Marienwerder, who supervised the construction of the Mühlhof dam, and he fully confirmed them.

Eels of 4 inches in length, which in May are plenty in fish-ponds, by the end of October reach a length of 10 inches and the thickness of a man's little finger; in the following fall they measure from 20 to 24 inches, and in the third year are ready to be eaten. On account of their rapid growth and hardy nature, in consequence of which latter they live in mud-holes and unprofitable waters of all kinds, the breeding of eels is a very remunerative business. The young fish (of which, at the time of their first appearance at the mouths of rivers, it takes 1,500 to 1,700 to make a pound, while, when taken later and a little further from the sea, it takes only 350 to 400 for the same weight) may be obtained at low prices from France through Hüningen, or in Germany from Randesberg and, through the Berlin Aquarium, from Wittenberg, and, when the temperature of the air is not too high, may be carried in soft moss throughout all Germany.

According to the statement of the well-known Paris fish-merchant, Millet, two pounds of eels, planted in a muddy pond in 1840, in five years yielded 5,000 pounds of fine eels.

XVIII. Observations of Dr. Hermes in 1881 on the conger.

The observations of Dr. Otto Hermes, director of the Berlin Aquarium, who has recently discovered the true nature of the organ of Syrski in the conger, are extremely interesting.

"Since Syrski, in 1874, found the organs in *Anguilla vulgaris*—which are called by his name, and which, by him and most zoölogists, were taken for the male reproductive organs—it is only necessary that a ripe male eel should be found in order to settle forever the question of the sexes of the eel. Up to this time all efforts have failed to reach the desired result. The histiological investigations of the Syrskian organs pursued by S. Freud render it more probable that these were young roes; yet there remained all the time a doubt, since the spermatozoa had not been actually observed, and this uncertainty is an insuperable obstacle to the acceptance of the Syrskian discovery. The supposed discovery of spermatozoa by A. S. Packard in the male eel proved to be another delusion. The contradiction of this imaginary discovery appeared in No. 26 of the second volume of the Zoologische Anzeiger, p. 193, in which it was stated that the motile bodies were not spermatozoa, but yolk particles. This correction was also made by Von Siebold's assistant, Dr. Paul,* and by S. Th. Cattie.

*Austrian Fishery Gazette, 1880, No. 12, p. 90.

"The reproductive organs of *Conger vulgaris* are very similar to those of *Anguilla vulgaris;* in the undeveloped condition they show the ovaries lying in the same position in a cuff-shaped band of a proportionally large size. Since *C. vulgaris* reaches nearly twice the size of *A. vulgaris*, individuals of 6 feet in length are not rare. The ovary is developed in the captivity, and this, I am convinced, is often the cause of the death of the eel. In a *Conger* which died in the Berlin Aquarium, and was cut open, the ovaries protruded very extensively, and a specimen which lies in the Frankfort Aquarium burst on account of the extraordinary development of the ovaries. The ovaries of this eel, which weighed 22½ pounds, themselves weighed 8 pounds, and the number of eggs was about 3,300,000. The want of a natural opening for the escape of the eggs was evidently in this case the cause of death. Male specimens of the *Conger* in an undeveloped condition I have hitherto never had the opportunity to investigate. I received, however, in the fall of 1879 a number of sea-eels, taken in the vicinity of Havre, whose average length was from 24 to 27 inches. These eels ate greedily and grew rapidly. Only one was tardy in its development, so that it could be easily distinguished from the rest. This, which was the smallest of the *Congers* in the aquarium, died on the 20th of June, 1880, and was examined by me on the same day. I was very much delighted when I found the sexual organs very different from those which I had ever noticed before. After a single cut into them, there flowed out a milky

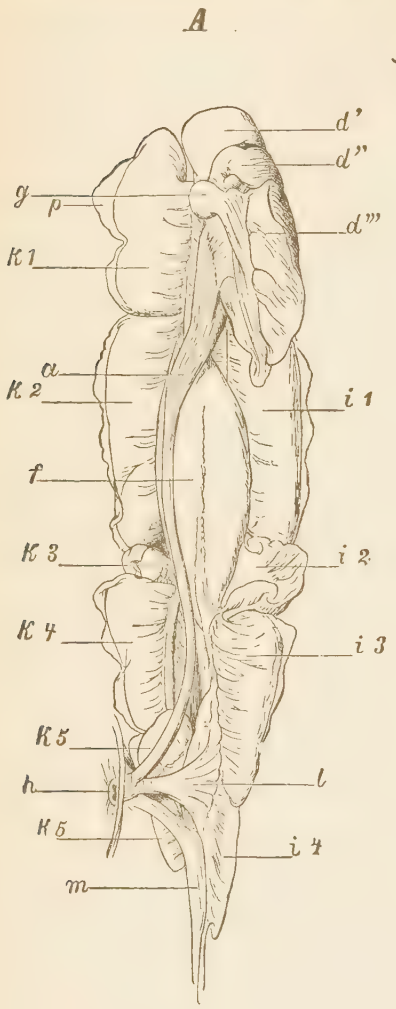


FIG. 9.—*A, ripe male reproductive organs of a Conger-eel, thirty inches in length, ⅛ natural size.*
a, intestinal canal.
d', upper, *d''* middle, *d'''* lower portion of the liver, which has been thrown to one side.
f, air-bladder.
g, gall-bladder.
h, anal aperture.
i_1, i_2, i_3, i_4, folds of the left spermary.
k_1, k_2, k_3, k_4, k_5, folds of the right spermary.
l, seminal pouch.
m, urinary bladder.
p, skinny covering of the spermary.
B, spermatozoa.

fluid, which, under the microscope, with a power of 450 diameters, showed a great number of spermatozoa, in the liveliest motion, and in which head and tail were evidently visible. There could be no doubt that I had found a sexually mature male of *Conger vulgaris*. Two fragments of the roe were laid aside for further investigation, and the eel, which was 28 inches long, was prepared first in alcohol and then in Wickersheimer fluid.

In the paper before us Dr. Jacoby presents a full anatomical description of the generative organs of the conger as demonstrated by himself and Dr. Rabl-Rückhard. It seems unnecessary to repeat this description since the organs are very similar to those in the common eel. By the kindness of Dr. Hermes we are permitted to reproduce the drawings which accompany this description.

Compared with the description of the roe and the figure of the organ found by Syrski and by me, called 'lappen organ,' a great similarity is noticed between them. It must be borne in mind that in this case we were comparing the entirely undeveloped organs of the eel with the fully ripe reproductive organs of the *Conger*, so every doubt as to the male nature of the Syrskian organs ought to be thrown aside. Also in the comparison of the size of the male with that of the female the *Conger* shows the same relations as the eel investigated by Syrski, to wit: that the males are smaller than the females.

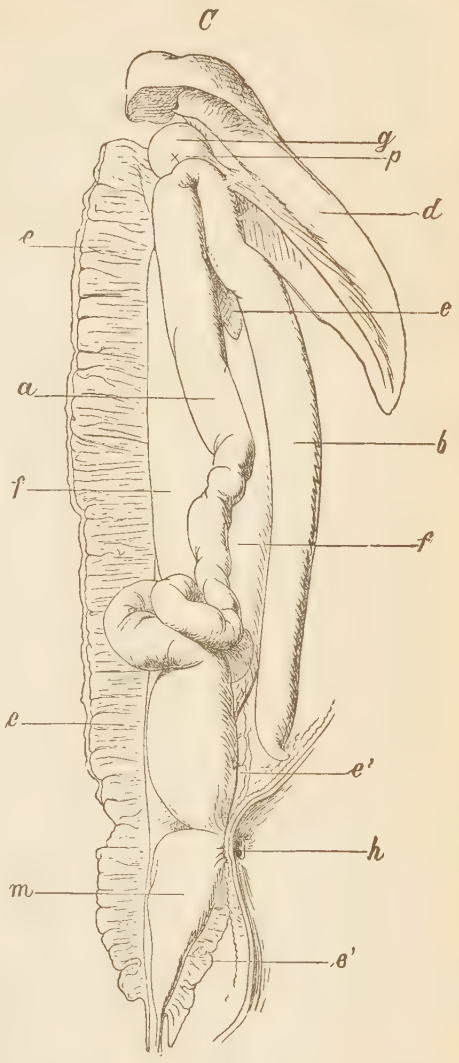


FIG. 10.—*C. Undeveloped reproductive organ of a female Conger-eel, 34 inches long, ⅓ natural size.*

a. Stomach.
b. Cœcal appendage.
c. Spleen.
d. Liver.
e. Right ovary.
e'. Left ovary.
f. Air-bladder.
g. Gall-bladder.
h. Anal aperture.
m. Urinary bladder.
p. End of left ovary.

It is well known, as Von Siebold remarks, that young eels, ascending the rivers, developed into females and that the males remain in the sea

or at the mouths of rivers. This statement cannot be exactly demonstrated, since among 250 eels, from 11 to 15 inches in length, taken in the vicinity of Cumlosen, I found 13 males or 5 per cent. (Cumlosen is situated in the vicinity of Wittenberg and is at least 120 miles from the mouth of the Elbe). How large the percentage of difference between the neighborhood of the mouth of Elbe and places situated farther up the stream, as regards the proportion of males and females, may be, I have hitherto, from want of material, been unable to decide. Forty from the Havel at Havelberg (about 20 miles above Cumlosen) were all females. Out of 137 eels taken in the bays at Rügen, in the Baltic, I found 61 or 44½ per cent. males, while at Wismar, on the Danish coast, the males only constituted 11 per cent. Whether these facts have any connection with the discovery of the hitherto unknown spawning places of the eels, it is hoped that further observations will determine.

When Cattie, in his already cited work, gives it as a determined fact that the eels wander into deep water here, in order to let their generative organs attain maturity, which happens in six or eight weeks, and that the old male and female eels, after the reproductive act, die, according to my knowledge, there are wanting observations which will give this a scientific foundation. What Von Siebold and Jacoby only state as probable appear to him (Cattie) to have become already established facts.

As far as the distinction between male and female eels by external characters is concerned, the eels sent to me, some time in November, from the coast of Schleswig showed so great difference in color that their sender, the fish-master Hinkleman, was able to decide without difficulty between males and females. The former were distinguished by a specially brown coloration, while the females, in addition to greater size, almost without exception exhibited a dull steel-gray color. Among the males were found many specimens of 17⅘ inches in length, which I was careful to note because Syrski had only found the size of 16⅘ inches. In Comacchio, according to Jacoby, a specimen of 18⅕ inches had been found.

XIX. Jacoby's tour to Comacchio in 1877, and his conclusions.

"In the fall of 1877," writes Jacoby, "I undertook a journey from Trieste, by way of Ravenna, to Comacchio; convinced of the difficulty of the questions to be solved by my own previous labors, I had not great hopes of finding sexually immature eels, either gravid females or mature males. My highest aim was at the beginning to determine the following points: (I) Whether evidences of preparation for breeding might not be found in the eels which were wandering in the fall toward the sea; (II) to what extent eels with the organ of Syrski could be found participating in this migration; (III) as far as possible to obtain eels from the sea at a distance from the coast in order to compare their organs of reproduction with those of the eels in the lagoons.

"In determining the answers to the first two questions I was able to make some new and interesting discoveries, but with regard to the latter, my most diligent efforts were absolutely fruitless.

"I found that the eels when migrating to the sea in the fall took no food. In many hundreds examined by me, caught during their movement, I found stomach and intestines entirely empty; that the eels during their migrations eat nothing is also known to all fishermen and watermen of Comacchio. At the same time, the eels which remained in the lagoons were more or less filled with food, not only those which were not sufficiently mature to migrate, but also a breed of eels which never goes to the sea, but remains throughout its entire life in the lagoons.

"There may be found in Comacchio, and doubtlesse verywhere where eels live in great numbers in brackish water along the coast, a peculiar group of eels which, as far as I could determine, consists entirely of sterile females. These female eels with ovaries present a very peculiar phenomenon; when they are opened one finds instead of the well-known yellowish-white, very fatty, cuff-shaped organ, a thin, scummy, slightly folded membrane, not at all fatty, often as transparent as glass, and of about the same proportional size as the so-called cuff-shaped organ. When this membrane is examined under the microscope there may be seen in it eggs very transparent in appearance, with yolk-dots absent or with yolk-dots very small and few. This organ appears to be an abnormally-developed ovary incapable of fertilization. These sterile females, which I found of all sizes, even up to the length of 27 inches, present all of the acknowledged female characters in great prominence and in an exaggerated degree; the snout is broader, and often, especially at the tip of the under jaw, extraordinarily broad; the dorsal fins are, on the average, higher; the eyes are much smaller, especially in large specimens, and the coloring is clearer; the back of a clearer green and the belly yellower than in the normal female. The flesh of these sterile females has a very delicate flavor, and quite different from that of other eels. I was quite astonished at the fine flavor when I tasted them for the first time in Comacchio. The flesh, as the expression goes, melts upon the tongue. It is even possible to distinguish them while living, by feeling them with the hand, their soft bodies being very different from the hard, solid, muscular flesh of the others.

"In Comacchio these eels are called 'Pasciuti.' Coste called them 'Priscetti,' and defined them to be those eels which had not become ripe, but which were at least a pound in weight. The name 'Priscetti' is, however, very incorrect, as I have become convinced by questioning the fish inspectors and by hearing the conversations of the fishermen. 'Pasciuto' means 'pastured,' and the fishermen understand by this, those eels which do not migrate, but which remain through the whole year feeding in the lagoons. They include, however, under this name, eels of two kinds—the sterile females already described, and the eels which are not yet ripe, as well as the normal females and supposed

males, whose period of migration is somewhat remote. This circumstance is a cause of much difficulty to the investigator.*

A.—Sterile females or Pasciuti.			B.—Normal Females.			C.—Eels with supposed male organs.		
	a.	*b.*		*a.*	*b.*		*a.*	*b.*
I.	508	10	I.	511	8	I.	—	—
II.	480	8.5	II.	497	7	II.	480	6
III.	458	11	III.	465	9	III.	470	6
IV.	443	9	IV.	447	7	IV.	445	5
V.	426	8.5	V.	425	6	V.	428	5
VI.	408	8	VI.	407	6	VI.	403	5
VII.	395	11†	VII.	396	7	VII.	396	5.5

"The studies on the second point to be solved were of special interest, viz, the determination of the presence at Comacchio, and the behavior of eels with organs of Syrski. I can answer this question very briefly, since among 1,200 specimens examined by me at the fishing stations and at the so-called eel-factories (with the exception of the largest specimens, which are always females), I found on an average of five per cent. with the organ of Syrski; of the eels under 15 inches in length (45 centimeters) on an average there were 20 per cent., so that the conclusions as to their abundance were very similar to those at Trieste, where the fish market is supplied, for the greater part, with eels from Chioggia, and to a less extent with those from Comacchio.

"In Comacchio the largest eels with the organ of Syrski, which I have observed, were about 17 inches (48 centimeters) in length, the smallest about 9 inches (24 centimeters). All of these were found among the eels taken during their migration to the sea, and, like the females, were found with stomachs completely empty or slightly filled with a slimy substance. It was impossible to find in any specimen a more advanced development of the Syrskian organ than in those examined in summer at Trieste.

"With reference to the third question undertaken by me, which relates to the actual kernel of the eel question, that is, the possibility of obtaining the eels which have migrated out to sea, in order to obtain in this manner the sexually mature milters and spawners, I have been unable to obtain any results. I have, so far as my opportunities permitted, left no stone unturned to gain its solution. I went out to sea

* It has been noticed by many early writers that there are certain eels which never come to the sea—Risso, in his "Histoire Naturelle," tome 3, p. 198, and S. Nilsson, in his "Scandinavisk Fauna," tome 4, p. 663. The latter called this variety "Grasaal," or grass-eel, and spoke of its yellowish-green coloration and the soft, delicious flesh. Strange enough, both these writers spoke of the sharper snout of this eel, and Risso, who founded upon it another species, *Anguila acutirostris*, described it as blackish above and silvery below. These descriptions apply in every particular to the non-migratory eel of Comacchio. Jacoby remarks that all the sterile females brought to him under the name "Pasciuti," were distinguished by their broad snouts. The following tables were prepared at Comacchio. *a* gives the total length of the body of the eel; *b*, the breadth of the snout between the nasal tubes, in millimeters.

from Magnavacca and from Codigoro, on Chioggian vessels, and many times have fished myself, and have stimulated the fishermen by offers of reward to endeavor to obtain eels at sea, but I am forced to the conclusion that with the ordinary means this cannot be done.

"Intelligent, grey-headed fishermen of Chioggia, who by means of their fishing apparatus know this part of the Adriatic as well as they know their own pockets, have assured me that throughout their entire lives they have never caught a grown-up river eel in the sea at any distance from the coast. The eels which were brought to me at Mannbach as having been caught in the sea, and which I found to be the ordinary females, or eels with the Syrskian organ, were either from localities close to the shore where they are not rare, or were taken in the Palotta canal. There was no lack of attempts at deception. Fishermen took eels from the shore with them in order to be able, on their return, to claim that they had been caught at sea. In the immediate neighborhood of the coast they are, as it has been stated, in the spring-time not rare, and there are not the slightest differences between these and the eels of the lagoons. I found both females and eels with the organ of Syrski with their reproductive organs in the same immature condition as in Comacchio; evidently they had just come through the Palotta canal from the lagoon into the sea. A certain distance, perhaps one or two marine miles from the coast, every trace is lost of the adult eels which wander by the many thousand into the sea. Strange as this problem appears at first sight, it is easily understood when the character of the fishing apparatus is considered; the nets are those used in the capture of lobsters, and are thrown over the bottom; they have meshes much too large to hold the eels, or, when they are small-meshed, they do not touch the bottom. The problem can only be solved by using apparatus constructed especially for the purpose."

Jacoby proposes the following questions, which, in his opinion, cover the still unanswered points concerning the natural history of the eel, and answers them in accordance with the results of his own observations:

Question 1. How can the fact be accounted for that no one has ever found mature females and males, spawners and milters, among the eels?

Answer. The eels require the influence of sea-water for the development of their reproductive organs. As is now definitely understood, they leave the rivers and the brackish lakes on account of the undeveloped condition of their reproductive organs, for the purpose of becoming sexually mature at sea; that these migrations to the sea take place for the purpose of reproduction appears to be certainly proved by the fact that the young eels leave the sea in the spring, and that the migrating eels, like other fishes at the spawning season, abstain from eating.

Question 2. When and where occurs the necessary development of the reproductive organs of the eel to a condition in which they are capable of fertilization?

Answer. Development of the reproductive organs takes place in the

sea, not close to the shore, but at a distance and in deep waters. This development is extraordinarly rapid when the immature state, in which the migrating eels are found, is taken into consideration; they must become sexually mature within a few, probably five or six, weeks of the time that they enter the sea. At Comacchio the emigration takes place between the beginning of October and the end of December.

Question 3. Where does the act of spawning take place, the fertilization, and the deposition of the eggs?

Answer. There are probably certain definite spawning places in the sea, off the mouths of the rivers. These are the mud-banks to which the eels go, for the purpose of spawning, in great numbers. The young fish are developed upon these mud-banks, and from eight to ten weeks after their birth, at the beginning of spring, find their way to the mouths of rivers, which they ascend.

Question 4. What becomes of the grown-up eels after spawning time, and why do they remain lost to sight and never again come back into the rivers?

Answer. The old eels, male and female, without doubt, die soon after the spawning season. The very unusual rapid development of their reproductive organs has such an effect upon the systems of the adult eels that they die soon after the act of reproduction. This is the reason why they are never seen to wander back again.*

An intelligent Chioggian, the owner of a fishing vessel, in answer to my question, as to where the old eels staid, answered, "They die on the mud-banks after they have propagated their young."

This hypothesis may be confirmed in a scientific manner by the analogous circumstances in the history of the lamprey. Panizza, in his description of the sea lamprey, *Petromyzon marina*, remarks, that both the males and females of this species after the spawning period are brought up dead. Concerning the river lamprey, *P. fluviatilis*, Statius Müller remarks that when they spawn they slowly fall away and die. Concerning the little lamprey, *P. planeri*, August Müller, the discoverer of its larval form, has recorded the same opinion.

XX.—A LIST OF THE MOST IMPORTANT PAPERS CONCERNING THE EEL AND ITS REPRODUCTION.

1684. REDI, FRANCISCO. Osservazioni intorno agli animali viventi che se trovano negli animali viventi. Florence, 1684.

["On living animals which occur within other animals." Refers to the mounting of the young eels in the Arno, and particularly to an enormous capture of young eels at Pisa, in 1667, [p. 100]. Illustrates the ovaries of a maray (*Muræna helena*). Proves that the objects ordinarily supposed to be young eels are intestinal worms, and argues that eels must be viviparous.]

* As a confirmation of this view, Von Siebold was the first to make this hypothesis.

1692. LEEUWENHOEK, ANTON DE. <Arcana Naturæ, 1692.

[Leeuwenhoek describes the urinary bladder of the eel as its uterus, and parasitic worms found therein as the young of the species.]

1697. ALLEN, BENJAMIN. On the Generation of Eels. <Philosophical Transactions, London, xix, 1697, pp. 664–666.

[Allen claimed that eels were ovo-viviparous.]

1698. DALE, —. An account of a very large eel lately caught at Malden, in Essex, with some considerations about the generation of eels. <Philosophical Transactions, xx, 1698, pp. 90–97.

1712. VALLISNERI, ANTONIO. De Ovario Anguillarum. <Ephemer. Leopoldinischen Academie der Naturforscher, 1712, pp. 153–165, Fig. 4.

[Contains an announcement of a supposed discovery of the ovary of the eel; the organ described by him was a diseased and deformed swimming-bladder.]

1746. ARDERON, WILLIAM. On the Perpendicular Ascent of Eels. <Philosophical Transactions, London, xliv, 1746, pp. 395–396.

1750. FAHLBERG, ALGOT. Von der Fortpflanzung und Vermehrung der Aale. <Abhandl. Schwed. Akad., xii, 1750, pp. 199–202.

[Not seen. Title from Syrski.]

1766. LINNÆUS, CAROLUS. Muræna Anguilla. <Systema Naturæ, i, 1766 (12th ed.), p. 426.

[Under the head of the eel, the father of modern natural history sums up its life history as known to him: "Habitat in Europa, maxima in lacu Comachio Ferrariensi; non fert Danubiam, nisi rarissime; nocturna latet in cœno duplici foramine, coercetur trunco albo betulæ; cutis tenacissima; parit vivipara sub canicula. * * * Hybernat; noctu tenebricosa obambulat; cadaveribus victitat."]

1777–83. MONDINI, CARLO. De Anguillæ Ovariis. <De Bononiensi Scientiarum et Artium Instituto atque Academia Commentarii, tom. vi, 1783, pp. 406–418. [Bologna, 1783.]

[Read before the Bologna Academy in 1877. After a comment upon the discovery of Spallanzani, which was shown to be untenable, the supposed ovary described by that investigator having been simply a diseased swim-bladder, Mondini describes the true ovary of the eel, illustrating his discovery by excellent drawings. In the opinion of Jacoby and others this was the first demonstration of the ovary of the eel.]

1780. MÜLLER, OTTO FRIEDRICH. Unterbrochne Bemühungen bei den Intestinalwürmern. <Schritten, Berliner Gesellsch. Naturf. Freunde, i, 1780, pp. 202–218.

[Announces the discovery of the ovary of the eels—a discovery independent from that of Mondini, though made three years later. Many authors have given the honor of discovery to Müller, owing to the fact that Mondini's paper, read to the Bologna Academy in 1777, was not published until 1783.]

1783. MONTE, CAJETAN. De Anguillarum Ortu et Propagatione. <Comment. Acad. Bonon., vi, 1783, pp. 392–405.

[1792?] SPALLANZANI, LAZZARO. Opusculi due sopre le anguille, dove singolarmente si ragiona di quelle che se pescano nelle valle di Comacchio. <Opere [ed. Milano, 1826], iii, p. 518. Apendice ai Viaggi alle due Sicilie, vi, [1752.]

[An attempt to overthrow the claim of Mondini.]

1803. AMORETTI, CARLO. Osservazioni sulle Anguille. <Mem. Soc. Italiana, x, 1803, pp. 679–680.

1807. MITCHILL, SAMUEL L. Facts concerning the Generation of Eels. <N. Y. Medical Repository, iv, 2d hexade, 1807, pp. 201–203.

[Records the independent discovery of eel ovaries in eels from Long Island.]

1809. CARR, JOHN. On the Generation and other obscure facts in the Natural History of the Common Eel. <Philosophical Magazine, xxxiv, 1809, pp. 272–277.

1815. CLINTON, DE WITT. An Introductory Discourse [before the Literary and Philosophical Society of New York], delivered on the 4th of May, 1814. <Trans. Literary and Philosophical Society of New York, ii, 1815, pp. 17–184.

[In note AA., pp. 146–148, Clinton expresses the following opinion: "The eels migrate every autumn to the sea for the purpose of propagation, and the young ones return up the streams in spring and summer in immense numbers. Some stay in fresh water all the year, but they do not breed; and it seems to be a fact well established that they do never breed in fresh water, the periodical descent of the old ones to the ocean and the ascent of the young ones from thence prove that the scene of their propagation is in the sea itself."]

1815. MITCHILL, SAMUEL L. The Fishes of New York described and arranged. <Trans. Literary and Philosophical Society of New York, i, 1815, pp. 355–492, 6 plates.

[Discussing the eel, p. 360, Mitchill remarks: "The roes or ovaries of eels may be seen, by those who will look for them in the proper season, like those of other fish. By inattentive observers they may be mistaken for masses of fat."]

1822. CARLISLE, ARTHUR. On the Breeding of Eels. <Philosophical Magazine, lix, 1822, pp. 109–110.

1824. RATHKE, MARTIN HEINRICH. Ueber den Darmkanal und die Erzeugungsorgane der Fische. <Neueste Schriften der Naturforschenden Gesellschaft zu Danzig, i, part iii, Halle, 1824, p. (122?); Wiegmann's Archiv, i, 1838, p. 299.

1828. MONDINI, CARLO. On the Generation and Migration of Eels. <Edinburgh Journal of Science, ix, 1828, pp. 328–330.

[Not seen. Title from Carus and Engelmann.]

1829. DAVY, Sir HUMPHREY. Salmonia, or Days of Fly Fishing, &c. London, 1829.

[Refers to the "eel-fairs" of England, describing the ascent of the young brood into Loch Erne.]

1831. YARRELL, WILLIAM. On the Generation of Eels and Lampreys. <Proceedings of the Committee of the Zoological Society, i, 1831, pp. 132–134.

1834. YARRELL, WILLIAM. On the Reproduction of the Eel. <Report, British Association for the Advancement of Science, 1833 (1834), pp. 446–447.

1838. RATHKE, MARTIN HEINRICH. Ueber die weibliche Geschlechtswerkzeuge des Aales. <Archiv für Naturgeschichte, iv, 1838, pp. 299–301.

1838. DESLONGCHAMPS, EUDES. Sur le Mode de Propagation des Anguilles. <L'Institut, vi, 1838; Suppl., pp. 133–134.

1839. JOANNIS, L. DE. Notice sur la Parturition et la Génération des Anguilles. <Revue Zoologique, 1839, pp. 48–53.

1839. JOANNIS, L. DE. Notice sur la Génération des Anguilles. <Comptes Rendus, Académie des Sciences, Paris, viii, 1839, pp. 301–312; L'Institut, vii, 1839, p. 67.

1842. HOHNBAUM-HORNSCHUCH, REINHOLD. De Anguillarum Sexu ac Generatione. Inaugural dissertation. Greifswald, 1842.

[According to Jacoby, this paper contained the first figure, since that of Mondini, of the ovary of the eel, and the first illustration of its appearance under the microscope.]

1845. PANIZZA, BARTOLOMEO. Memoria sulla Lampreda Marina. <Mem. dell' Instituto Lombardo di Scienze, Milano, ii, 1845, p. 48.

[Panizza here refers to the death of male lampreys after their reproductive functions have been performed.]

1848. SCHLÜSER, GUILIELMUS. De Petromyzontum et Anguillarum Sexu. Inaugural dissertation. Dorpat, 1848. 8°. p. 42.

[In this paper, according to Jacoby, Schlüser contradicts the opinion of Hornschuch that eels might possibly be hermaphrodite, advancing the idea that male eels are either very few in number or that they differ much from the females in size or appearance.]

1841. CREPLIN, FRIEDRICH CHRISTIAN HEINRICH. Ueber die Fortpflanzungsweise des Aals. <Archiv für Naturgeschichte, vii, 1841, pp. 230–232.

1842. WIDDRINGTON, S E. [Captain, Royal Navy]. On the Eel and the Fresh-water Fish of Austria. <Annals of Natural History, viii, 1842, pp. 207–210.

[Claims that the absence of eels in the lower Danube is due to the admixture of water from cold Alpine streams.]

1850. RATHKE, MARTIN HEINRICH. Bemerkungen über einen hochträchtigen Aal. <Müllers Archiv für Anatomie und Physiologie, i, 1850, pp. 203–206.

[For comment on the work of Rathke, see the translation of Jacoby's memoirs, Report U. S. Fish Commission, iii, (1874), 1876, p. 727.]

1850. COSTA, ORONZ. GABRIEL. Storia ed Anatomia dell' Anguilla e Monografia della nostrali Specie di questo Genere. Naples, 1850. 4°, with 9 plates.

1859. VOGT, CARL. "Künstliche Fischzucht." Leipzig, 1859.
[Refers to the mounting of the young eels in France, p. 52.]

1861. COSTE, P. Voyage d'Exploration sur le Littoral de la France et de l'Italie. Paris, 1861.
[On p. 49 Coste discusses the peculiar supposed sterile forms, known in Comacchio by the name "*Pascente.*"]

1863. SIEBOLD, CARL THEODOR ERNST VON. Die Süsswasserfische Mitteleuropas. Leipzig, 1863.
[In this work, pp. 348–352, von Siebold suggests the idea that the sedentary eels of the inland waters were permanently sterile individuals. He admits that the eels may reproduce either by parthenogenesis, by copulation, or that they may even be hermaphrodites.]

1866. DESMAREST, M. <Revue et Magazin de Zoologie, 1866, pp. 161–165.
[Observations on an eel kept in a tank of water for the last thirty-seven years.]

1867. JACOBY, L. Ueber den Knochenbau der Oberkinnlade bei den Aalen. < Inaugural dissertation of L. Jacoby, with 8 plates. Reprinted in Giebel & Sieweit's Wissenschaftliche Zeitschrift, Sept. and Oct., 1867. Halle, 1867.
[Concerning the bony structure of the upper jaw of the eel.]

1872. ERCOLANI, GIOVANNI BATTISTO. Del Perfetto Ermafroditismo delle Anguille. < Mem. dell' Academia delle Scienze di Bologna, 1872, p. 529.
[In this paper "Upon the perfect hermaphroditism of eels," Ercolani maintained that the snaky-like folds of fat formerly noticed near the ovary were nothing else than the true spermaries of the eel, and that upon the left side of the animal the spermary developed into a true testicle, while the one upon the right side shrunk up and became functionless. The spermatozoa (supposed) observed by him have been pronounced by Syrski and others to have been founded on a false interpretation of the molecular movement of the fat particles.]

1872. BAIRD, SPENCER F. Generation of Eels. < Annual Record of Science and Industry, 1872 (1873), p. 299.
[A review of Ercolani's paper.]

1872. CRIVELLI, BALSAMO, and MAGGI, L. Intorno agli Organi Essenziali della Reproduzione delle Anguille. < Mem. del Instituto Lombardo di Scienze e lettere a Milano, xii, 1872, pp. 229–240, with plate; Wiegmanns Archiv für Naturgeschichte, I, 1872, p. 59 (German translation). Review by Canestrini, Atti Soc. Padua, i, 1872, pp. 70–74.
[In this paper, read fourteen days later than that of Ercolani, the authors, like Ercolani, considered the folds of fat next to the ovary to be the male organs. While they, too, advocated the hermaphroditism of the eel, they maintained that the active male organ was located upon the right side of the animal. They described spermatozoa (supposed) found by them in this organ.]

1874. DARESTE, CAMILLE. Monographie de la Famille des Poissons Anguilliformes. <Comptes Rendus de l'Académie des Sciences, Paris, lxxix, pp. 988–990.

[An abstract of this paper is given above in the section on number of species of eels.]

1874. EBERHARD, Dr. R. [of Rostock]. Die Fortpflanzung des Aales. <Gartenlaube, 1874, p. 120.

[Identifies the young of *Zoarces viviparus* as young eels.]

1874. SYRSKI, Dr. [Professor in University of Lemburg.] Ueber die Reproductions-Organe der Aale. <Sitzungsb. d. k. Akad. d. Wissensch., Wien, lxix, 1874, April, pp. 315–326, 2 cuts. [Dated Trieste, March 15, 1874.]

[The famous paper in which the discovery of the male eel was announced.]

1875. SYRSKI, Dr. Degli Organi della Reproduzione e della Fecondazione dei pesci ed in specialità delle Anguille. <Bolletino delle Società Adriatica di Scienze Naturali in Trieste. No. 1, pp. 10–32, Dec. 1874. Trieste, 1875 (with figures).

[Translated for Report of U. S. Fish Commission. Part iii, pp. 719–734. See below.]

1875. WITTMACK, Dr. LUDWIG. Beiträge zur Fischerei-Statistik des deutschen Reichs sowie eines Theiles von Oesterreich-Ungarn und der Schweiz im Auftrage des Deutschen Fischerei-Vereins bearbeitet von Dr. L. Wittmack. Circular des Deutschen Fischerei-Vereins, i, 1875. 4°, pp. 251, (1) 2 folding tables and a map. The Eel, pp. 124–129.

[An excellent summary of facts concerning the distribution of the eel in Germany, with special reference to physical characters of the water, also discussions of mooted points in its life history, and statistics of its capture and use.]

1875. DARESTE, CAMILLE. Résumé d'une Monographie des Poissons Anguilliformes. <Archives de Zoologie Expérimentale et Générale, Paris, iv, pp. 215–325; Comptes Rendus de l'Académie des Sciences, Paris, lxxxi, pp. 159–162; Annals and Magazine of Natural History, (4), xv, p. 304, xvi, p. 442.

[Confirms the observations of Syrski. Records discovery of males of *Anguilla marmorata*, a species native to India.]

1876. DE LA BLANCHÉRE, H. Génération de l'Anguille. <Bulletin de la Société d'Acclimatation, 3me sér., iii, 1876, pp. 489–494.

[Confirming the discovery of Syrski from observations in France.]

1876. DUIGAN, J. Is Access to the Sea a Necessity to Eels? <Transactions New Zealand Institute, viii, pp. 221.

[Claims that eels thrive in certain land-locked lakes in New Zealand where access to the sea is impossible.]

1876. SYRSKI, Dr. Lecture on the Organs of Reproduction and the Fecundation of Fishes, and especially of Eels. <Report U. S. Fish Commission, iii (1874), 1876, pp. 719–734, 23 figures.

1877. DALLMER, Herr [Head Fishmaster in Schleswig]. Fische und Fischerei im süssen Wasser. Segeberg, 1877.

[An account of young eels found in an empty sack in which dead eels had been transported. Not seen. Title from Benecke.]

1877. LAND, GORDON. Fresh and Salt Water Eels. <Forest and Stream, viii, 1877, p. 261.

[Records capture of eels in Grand River, a tributary of Lake Erie on Canada side; in Conejos River, 1,000 miles from Gulf of Mexico, and in tributary Platte River above Denver, Colo.]

1877. ROOSEVELT, ROBERT B. New Discoveries respecting Eels. <Forest and Stream, viii, 1877, p. 267.

[Advances the idea that eels lived in fresh water in his trout ponds on Long Island.]

1878. DALLMER, Herr. Ueber die Fortpflanzung der Aale. <Deutsche Fischerei-Zeitung, i, 1878, pp. 1–3, 9–10, 17–18.

[This interesting paper is discussed in above in section xiii. A translation in part appeared in *Chicago Field*, 1878.]

1878. SCHOCH, Dr. GUSTAV [of Zurich], and Head Fishmaster DALLMER. Noch ein Beitrag zur Aalfrage. <Deutsche Fischerei-Zeitung, i, 1878, pp. 57–58 (Feb. 19).

[A discussion between Schoch and Dallmer in which there are many words and few demonstrations. Dr. Schoch, of Zurich, presents the following conclusions stated to him by Jacoby as summing up the points which may be considered as essentially substantiated: First, the eel is a fresh-water fish, which passes the greater part of its life in fresh water, but spawns in the sea. Second, it is extremely improbable that the eel brings forth living young. Third, the river eel of the headwaters or upper portion of the rivers is almost always a female, with undeveloped ovaries. Fourth, at the age of four years the eel goes down to the sea to spawn, and never returns to the fresh water. Fifth, by the deposit of the eggs the life of the female is greatly endangered, sometimes eels being found by thousands near the mouths of rivers with the ovaries entirely empty. Sixth, the descent of the eel to the sea does not appear to take place at any definite period; it probably, however, relates to the spawning season. Seventh, the male eel is always much smaller than the female, none of the former being known over fifty centimeters in length. Eighth, the males never ascend high up toward the headwaters of the rivers, but keep either continually in the sea or in the brackish water or the lower reaches of the stream. Thus a male eel has never been found in the Rhine from Basle upward. Ninth, nothing is known definitely about the spawning season. Tenth, according to all that is known, it is probable that the eels spawn in the deep sea, perhaps not very far from the mouths of the rivers.]

1878. ABBOTT, C. C. Notes on Fishes of the Delaware River. <Report U. S. Fish Commission, iv, 1875–'76 (1878), pp. 826–845 (p. 82).

[Abbott acquits the common eel of the charge of destroying large quantities of ova of other fish, but states that this is a characteristic habit of the lamprey. This fish, which is found occasionally hibernating in the soft mud at the mouths of some of the inflowing creeks, appears to come from the bay or

1878. ABBOTT, C. C.—Continued.

ocean (at any rate, from the lower portion of the river) in immense numbers, early in March, and remains about the rocks at the head of tide-water for some time, as though waiting for the coming shad and herring. With the shad they pass up the river beyond tide-water, and in the rapid, rocky portions of the river, having deposited their own ova, they wander over the breeding grounds of other fishes, and devour every egg they can find. "I have found lampreys in Crosswick's Creek in the month of May gathering up the eggs from sunfishes' nests; and several times, when at the shad fisheries, I have taken small lampreys—from five to seven inches in length—that were attached to shad, with their sucking disks (mouths) firmly closed on the vaginal orifice, through which they were sucking the eggs."]

1878. KAUMANN, Herr [of Halle]. Zur Aalfrage. < Deutsche Fischerei-Zeitung, i, 1878, pp. 214–215, June 2.

["On the eel problem." Generalizations, apparently of little moment.]

1878. N. Y. EVENING POST. Where do Eels Breed? Seth Green's solution of a piscatorial problem. < N. Y. Evening Post, Aug., 1878.

[Seth Green maintains that eels breed only in salt water; describes the mounting in the Hudson River, and, *mirabile dictu*, says that eels are hybrids (of what origin not stated), and that they never contain eggs or reproduce their own kind. Mr. Green's views are doubtless misrepresented by the reporter.]

1878. FINN, W. [of Berlin]. Zur Aalfrage. < Deutsche Fischerei-Zeitung, i, 1878, p. 254, Aug. 13.

["On the eel question." Herr Finn calls attention to criticisms on Dallmer's paper by Gerhard v. Yhlen, of Sweden, and Arthur Feddersen, of Denmark, and suggests several objections to the idea that eels are born only in salt water.]

1878. SELLIN, W. ["On Nematoid Parasites mistaken for Young Eels."] < Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg, xxxi, 1878, pp. 111–112.

[Not seen. Title from Zoological Record.]

1878. EDITORIAL. Propagation of Eels. < Sunbury (Pa.) American, Aug. 21, 1880.

[Quoting from London "Country" and "Augsburger Abend-Zeitung" Eberhard's observations.]

1878. BAIRD, SPENCER F. Propagation of Eels. < Sunbury (Pa.) American, Aug. 30 or Sept. 6, 1878.

[Letter, dated Gloucester, Aug. 27, 1878, criticising Eberhardt's article on propagation of eels, first published in the *Gartenlaube*.]

1878. MATHER, FRED. An Eel has 9,000,000 Eggs. < N. Y. Times, Dec. 13, 1878.

1878. ANONYMOUS. Professor Packard's Discovery. < N. Y. Sun, Dec. 8, 1878.

1878. ROOSEVELT, ROBERT B. Habits of Eels. < Forest and Stream, June 13, 1878.

[A reiteration and recapitulation of the claims that eels spawn in fresh water in the writer's Long Island ponds.]

1878. ROOSEVELT, ROBERT B. Reproductive Habits of Eels. <Transactions of the American Fish Cultural Association, seventh meeting, 1878, pp. 90–98.

[Mr. Roosevelt maintains that eels were hatched in fresh water in his trout ponds, on Great South Bay, Long Island.]

1878. CAPE ANN ADVERTISER. Bobbing for Eels by Moonlight. <Cape Ann Advertiser, July 19, 1878, p. 2.

1878. CAPE ANN ADVERTISER. The Eel Fisheries of South Deer Isle, Maine. <Cape Ann Advertiser, Dec. 20, 1878, p. 4.

1878. "ONCE A FISHERMAN." The Great Eel Question. <N. Y. Evening Post, Oct. 4, 1878.

[Another man who mistakes intestinal worms for small eels.]

1878. SCHMIDT, Herr. ["On the Economy of the Eel."] <Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg, xxxi, pp. 102–110.

[Not seen. Title from Zoological Record.]

1879. ROOSEVELT, ROBERT B. Reproductive Habits of Eels. <Transactions American Fish Cultural Association, eighth meeting, 1879, pp. 32–44.

[A summation of recent discoveries, the author still maintaining that eels breed in fresh water.]

1879. SAWYER, J. G. [of Sawmill Rift, Pike Co., Pa.] That Male Eel. <New York Sun, May 17, 1879.

[An observer forty years familiar with the fisheries of the Delaware River describes the differences between male and female eels; gives an account of the mounting of the young eels in the Delaware about June 1, and speaks of the abundance of eels in Metaqua Pond, Sullivan County, and other inland waters in that vicinity separated from the sea by high waterfalls.]

1879. PUTNAM, FREDERICK W. "Mr. F. W. Putnam exhibited a specimen of the common eel (*Anguilla bostoniensis*)." <Proceedings Boston Society of Natural History, xix, 1879, pp. 279–280.

[Notes on recent history of this discussion. Attention called to the eggs in the specimens exhibited, all of which were "silver bellies." The question asked, "Will 'golden bellies' prove to be males?"]

1879. DUNKER. Geht der Aal in Erbsenfelder? <Deutscher Fischerei-Verein, ii, 1879, Nov. 4, pp. 357–358.

["Do eels frequent pea-patches?"—a discussion of the question.]

1879. NICKLAS, CARL. Der Aal (*Anguilla vulgaris*). <Deutscher Fischerei-Verein, ii, 1879, Oct. 7, pp. 326–328. Extract from "Lehrbuch für Teichwirthschaft."

[A popular synopsis of the natural history of the eel from the standpoint of the fish-culturist.]

1879. HAACK, H. Die Einführung von Aalbrut in deutsche Gewässer. <Deutsche Fischerei-Zeitung, ii, 1879, March 4, p. 65.

[Practical suggestions to fish-culturists concerning the planting of young eels.]

1879. PACKARD, A. S., jr. The Breeding Habits of the Eel. <American Naturalist, xiii, 1879, pp. 25–30, and 125 (a correction).

[On the 18th and 20th of February, 1879, Dr. Packard found three specimens which were supposed to contain the organs of Syrski, and in which he thought he detected the presence of living spermatozoa. He subsequently came to the conclusion that the movements observed by him were simply Brownian movements among the fat corpuscles, and that the supposed spermatozoa were only yolk particles. See, also, Zoologischer Anzeiger, April, 1879, p. 193; Jan. 13, 1879; April 21, 1879.]

1880. BALLOU, WILLIAM HOSEA. Eels (*Anguilla acutirostris*). <Chicago Field, xiv, 1880, pp. 291–292.

[A description of the eel fisheries of Oswego River, New York. Claims that eels spawn in Oneida Lake.]

1880. HERMES, Dr. OTTO [Director, Berlin Aquarium.] Ueber Aalbrut und Aufzucht junger Aale. <Circular, Deutscher Fischerei-Verein, 1880, Feb. 12, No. 1, pp. 23–25.

["Concerning young eels and their propagation." Describes the mounting of the young eels in June in the river Elbe; gives directions for transporting young eels.]

1880. HERMES, Dr. OTTO. Ueber Aalmännchen und Aalweibchen. <Circular, Deutscher Fischerei-Verein, 1880, No. 2, March 27, pp. 55–57, cut.

["Concerning male eels and female eels." Dr. Hermes gives a brief history of the search for male and female eels, with an account of the discovery of male eels by Syrski. He recounts the external and internal marks of males and females, as indicated by Syrski and Jacoby.

Dr. Hermes, visiting the fish market of Trieste in company with Dr. Syrski, found fifteen males among twenty selected according to these indications, but in Berlin could find none. He indorses the opinion that males occur as a rule only in the sea and in the mouths of rivers. He calls attention to the importance of searching for male eels on the coasts of the German Ocean and the Baltic, and advises that examinations shall be confined to examples less than 18 inches long, since the male eel rarely exceeds this size.

1880. HERMES, Dr. OTTO. Zur Fortpflanzung des Aals. <Deutsche Fischerei-Zeitung, iii, 1880, June 8, pp. 244–245.

[Announces the discovery of male eels in the Baltic. Dr. Hermes examined two lots of 72 each of eels 38 to 42 centimeters long, one lot from Wismar, another from the region between Seeland and Laland. In each of these lots he found 8 males.]

1880. HERMES, Dr. OTTO. Zur Fortpflanzung des Aales. <Circular, Deutscher Fischerei-Verein, vi, 1880, Nov. 25, pp. 197–201, 2 cuts; Zoologischer Anzeiger, 1881, No. 74, pp. 39–44.

["On the reproduction of the eel."]

1880. HERMES, Dr. OTTO. Ueber Aalbrut und Aufzucht junger Aale. <Oesterreich-Ungarische Fischerei-Zeitung, i, 1880, No. 11, March 16, pp. 83–84.

[Dr. Hermes suggests methods for the transportation of young eels.]

1880. HAACK, H. Acclimatisirung des Aales im Donaugebiete. <Oesterreich-Ungarische Fischerei-Zeitung, i, 1880, No. 9, March 1, p. 65.

["The acclimatization of eels in the Danube" Haack proposes to effect by transporting several hundred thousand young eels (montée) from near the mouths of rivers before the young males have dropped out in the course of their upward ascent.]

1880. LINDENHAIN, GUIDO. Zur Naturgeschichte der Aale. <Oesterreich-Ungarische Fischerei-Zeitung, i, 1880, No. 6, Feb. 8, pp. 46–47; No. 7, Feb. 16, p. 54; No. 8, Feb. 23, p. 60; No. 9, March 1, p. 68; No. 10, March 8, p. 75; No. 11, March 16, pp. 84–85.

[A very worthless compilation, subsequently severely criticised by Dr. Pauly in the same periodical.]

1880. PAULY, Dr. A. Die Fortpflanzung des Aales (*Anguilla vulgaris* Fleming). <Oesterreich-Ungarische Fischerei-Zeitung, i, 1880, No. 12, March 23, pp. 89–90; No. 48, Dec. 23, pp. 389–390 (correction to first article).

[This essay, drawn out by Lindenhain's pretentious and mendacious article on the natural history of the eel, gives a very clear and sensible exposition of the present state of knowledge upon the reproduction of the eel, as well as a satisfactory historical résumé of the subject.]

1880. [BENECKE, BERTHOLD.] Vom Aal. <Berichte, Ost- und West-Preussischen Fischerei-Vereins, 1880, May, pp. 33–36, 4 figs.; Deutsche Fischerei-Zeitung, iii, Feb. 3, 1880, p. 44.

[General natural history. These articles were incorporated in the author's later work.]

1880. GLÖCKNER GEBRÜDER. Aalbrut. <Deutsche Fischerei-Zeitung, iii, 1880, May 25, p. 217.

[Narrates that young eels were planted in the river Tschirne in 1877, and that after an extraordinary freshet in 1880, by which for the first time since 1845 the water was raised higher than a dam at the entrance to a small pond, young eels were found in that pond. Suggests that there were eels of three years' growth.]

1880. DUNKER, Herr [of Stettin]. Der Aal auf der Ausstellung. <Deutsche Fischerei-Zeitung, iii, 1880, May 25, pp. 218–219, with cut.

[An account of the male eels exhibited at the Berlin Fishery Exhibition, with a history of recent investigations and discoveries.]

1880. DUNKER, Herr. Vom Aale. <*Ibid.*, iii, 1880, March 31, p. 113.

[Concerning the migrations of eels, old and young.]

1880. DANNER, HERMANN. Der Aal geht aufs Land. <Deutsche Fischerei-Zeitung, iii, 1880, Oct. 26, p. 422.

["Eels go over the land." Narrates two instances where eels have escaped from tanks, and have been found at considerable distances in ditches and under stones.]

1880. MCGOVERN, HUGH D. On the Curious Habits of Eels. <Trans. American Fish Cultural Association, 1880, pp. 19–20.

[Note on the climbing power of young eels.]

1880. JACOBY, L. Der Fischfang | in der Lagune von Comacchio | nebst einer | Darstellung der Aalfrage | von | Dr. L. Jacoby. | Mit zwei Tafeln. | Berlin, 1880. | Verlag von August Hirschwald. | n. w. Unter den Linden, 68. | 8°. pp. vi, 93 (1), plates, map.

[A thorough and scholarly review of the whole history of the eel, with a full account of the eel-fishery in the lagoon of Comacchio.]

1880. CATTIE, S. TH. Ueber die Genitalien der männlichen Aale und ihre Sexualunterschiede, von S. Th. Cattie., Phil. Nat. Cand., Docent an der Realschule zu Arnheim, Holland. <Zoologischer Anzeiger, June 7, 1880, pp. 275–279, 2 cuts. Also, in translation, "On the Genitalia of Male Eels and their Sexual Characters." <Proceedings U. S. National Museum, iii, 1880, pp. 280–284. [Translated by John A. Ryder.]

[Gives a description of the internal and external characters of male eels.]

1880. BENECKE, BERTHOLD. Fische, Fischerei, und Fischzucht | in | Ost- und Westpreussen. | ——— | Von | Dr. Berthold Benecke, | Professor an der Universität Königsberg. | Mit zahlreichen Abbildungen von Braune. | [Erste Lieferung.] | ——— | Königsberg in Pr. | Hartungsche Verlagsdruckerei | 1880. 8°. pp. —. [Unfinished; 320 pages published up to date.] The Eel, pp. 173–188.

[A masterly review of the present state of knowledge upon the history of the eel.]

1881. ROBIN, C. The Male Eels compared with the Females. <Annals and Magazine of Natural History, (5), vii, May, 1881, pp. 386–392. [Translated from Comptes Rendus, Feb. 21, 1881, pp. 378–383.]

[Describes the male and female organs, and calls attention to the paper of Duvernoy, who, in his judgment, described correctly the ruffle-like or male type of the genitalia of the eel. Except for this, the paper is, like those of Dareste, Cattie, and others, simply a confirmation and extension of previous observations.]

1881. HERMES, Dr. OTTO. Zur Fortpflanzung des Aales. <Circular, Deutscher Fischerei-Verein, 1881, No. 1, Jan. 31, pp. 17–18.

["On the reproduction of the eel." States the fact that, according to the observations of Upper Fishmaster Dallmer, the eels taken from August to November (especially in September and October) in the Baltic along the Flensburg-Alsen coast and in the Lesser Belt were apparently migrating from the south to the north, this being indicated by the manner in which the leaders of the eel-pots were attached—to wit, to the northern wing of the eel-pot.]

1881. HERMES, Dr. OTTO. Zur Aufzucht junger Aale. <Circular, Deutscher Fischerei-Verein, i, 1881, Jan. 31, pp. 20–21.

["On the propagation of young eels." An argument in favor of selecting for transplanting into land-locked waters eels between one and two years of age, rather than the miniature fish usually used for that purpose.]

1881. HINCKELMANN, Herr [Fishmaster at Flensburg]. Beitrag zur Naturgeschichte des Aals. <Circular, Deutscher Fischerei-Verein, i, 1881, Jan. 31, pp. 18–19.

["A contribution to the natural history of the eel." Notes on the periods of greatest abundance of eels about Flensburg and on the Danish coast. Hinckelmann speaks of the size of the eels at different seasons, and of the influence of the weather upon their capture. He confirms the view that eels migrate in the fall from south to north, or from brackish toward salt water, stating that the earliest catches are made at the south, the latest in the most northern localities.]

1881. DECKER, Herr [Fishmaster of Altona]. Zur Naturgeschichte der Aale. <Deutsche Fischerei-Zeitung, 1881, May 24, pp. 165–166.

[An interesting communication, claiming that eels spawn and are hatched on muddy and slimy bottoms at a depth of ten to fifteen feet.]

A LIST OF OHIO RIVER FISHES SOLD IN THE MARKETS.

By ORLANDO HOBBS.

JEFFERSONVILLE, IND., *March* 20, 1881.

Prof. SPENCER F. BAIRD,

Secretary Smithsonian Institution:

DEAR SIR: Mr. Luke, the postmaster at this place, called on me to furnish a list of the fish caught at the Falls of the Ohio. I was very unwell at the time, and too much occupied with business affairs to attend to it at that time. I have since, by going to the fishing grounds, seeing the lines run and the captures by the nets, been enabled to make the following list, that comprises about all the fish caught here. I also send with this a list written and furnished by William Taylor & Co., who have fished here and supplied the market for the last forty years. They claim it is a full list, and it agrees with that I have collected from every other source of information. Should there be anything you wish information of at this locality, and will send directions for properly obtaining the same, it will give me pleasure to attend to it for you.

I have the honor to remain, very respectfully, yours,

ORLANDO HOBBS.

LIST OF FISH CAUGHT AT FALLS OF OHIO.

Stizostethium vitreum var. *salmoneum* (Raf.), Jor. & Copeland.—White Salmon.
Stizostethium vitreum (Mitch.), Jor. & Copeland.—Black Salmon.
Percopsis guttatus, Ag.—Trout Perch.
Perca fluviatilis, Linn.—Yellow Perch.
Pomoxys annularis, Raf.—White Perch, Bachelor Perch.
Bubalichthys urus, Ag.—Black Buffalo.

Ichthyobus bubalus, Ag.—Buffalo Perch.
Cycleptus elongatus, Raf.—Long Buffalo.
Exoglossum maxillingua, Raf.—Stone-Toters.
Carpiodes ———, Raf.—Carp.
Catostomus commersonii (Lac.), Jor.—Sucker.
Myxostoma macrolepidota var. *duquesnii* (Les.), Jor.—Red Horse.
Myxostoma macrolepidota var. *macrolepidota* (Les.), Jor.—Black Horse.
Ptychostomus ———.—Mullet.
Pomolobus chrysochloris, Raf.—Skip-jack, Ohio Herring.
Alosa sapidissima (Wilson), Storer.—Sea Shad, Potomac Shad.
Dorysoma cepediana (Les.), Gill var. *heterura* (Raf.), Jor.—Hickory Shad.
Ambloplites rupestris (Raf.)—Rock Bass, Goggle-eye.
Hyodon tergisus, Les.—Tooth Herring.
Lepomis ———, Gill.—Common Sunfish.
Micropterus pallidus (Raf.), Gill & Jor.—Black Bass.
Micropterus salmoides (Lac.), Gill.—Yellow and Green Bass.
Semotilus ———, Raf.—Common Chub, Silversides.
Ceratichthys, Baird.—Horned Chub.
Ichthælurus punctatus (Raf.), Jor.—Blue and Channel Cats.
Amiurus ———.—Yellow Cats.
Amiurus ———.—Bull-head Cats.
Pelodichthys olivaris (Raf.), Gill & Jor.—Mud Cats.
Polyodon folium, Lac.—Spoon-bill Sturgeon.
Acipenser rubicundus, Les.—Red Sturgeon.
Scaphyrhynchops platyrhynchus (Raf.), Gill.—Shovel-nose Sturgeon.
Lepidosteus osseus (L.), Ag.—Gar Pike.
Litholepis spatula (Lac.), Jor.—Alligator Gars.
Lepidosteus platystomus, Raf.—Short-nose Gar-Fish.
Anguilla rostrata (Les.), DeK.—Yellow or Golden Eel.
Anguilla rostrata.—Common Black Eel.
Snapping Turtle, Black and Yellow Soft-shell Turtles, Water Dogs.

NAMES OF OHIO RIVER FISH.

William Taylor & Co.'s list of fish.

White Salmon.
Black Salmon.
White and Yellow Perch.
Yellow and Blue Cats.
Black Buffalo.
Buffalo Perch.
Carp.
Tooth Herring.
Rock Bass.
Black and Yellow Bass.
Green Bass.
Sunfish.
Stone-Toters.
Black and Red Horse.
Spoon Bills.
Hickory Shad.
Grindel and Pike.
Jackfish, Silversides.
Coal Boat Cat.
Mullet.
Potomac Shad.
Goolem.
Sturgeon.
Dogfish.
Flat and Bull-head Cat.
Silver and Gold Eel.
Bachelor Perch.
Goggle-eye.
Chub.
Skip-jack.
Shovelfish.
Horned Chub.
White Shovelfish.
Water Dog.
Black and Yellow, Hard and Soft shell Turtle.

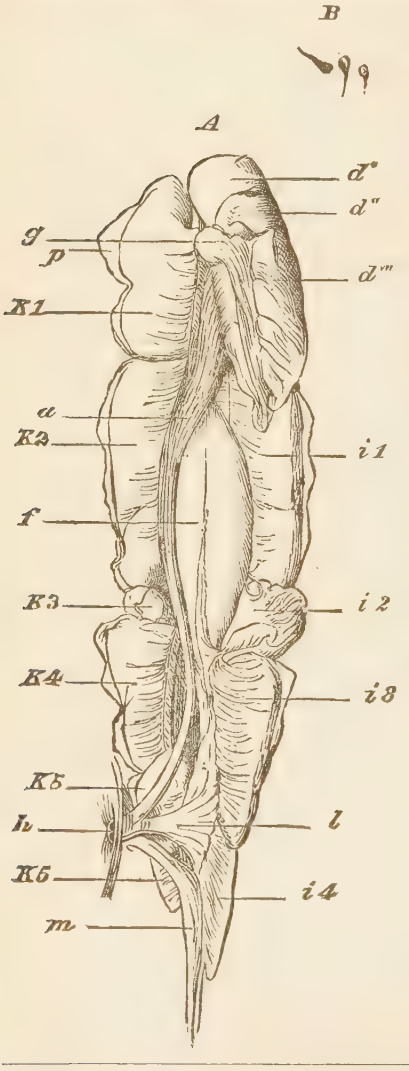
NOTE.—The scientific names of the fish, as given by Mr. Hobbs, have been changed to make them agree with recent nomenclature. In some cases it is not certain that the species indicated is really the species of the market.—ED.

ON THE MATURE MALE SEXUAL ORGANS OF THE CONGER-EEL (*Conger vulgaris*), WITH SOME OBSERVATIONS ON THE MALE OF THE COMMON EEL (*Anguilla vulgaris* Fleming).*

By Dr. OTTO HERMES,

Director of the Berlin Aquarium.

Since Syrski, in 1874, discovered the organs in *Anguilla vulgaris*, which have been named after him, and which have been regarded as the male reproductive organs by himself and most other zoologists, the discovery of a sexually mature male only remained to be made to finally settle the question of the sex. Up to the present time all the efforts made to attain this desired result have been fruitless. The histological investigations pursued by S. Freud upon the Syrskian lobulated organs, seemed indeed to lead with greater probability to the conclusion that they were testicular in nature, nevertheless the failure on all hands to find spermatozoa remained the missing link in the chain of evidence needed to confirm Syrski's discovery.



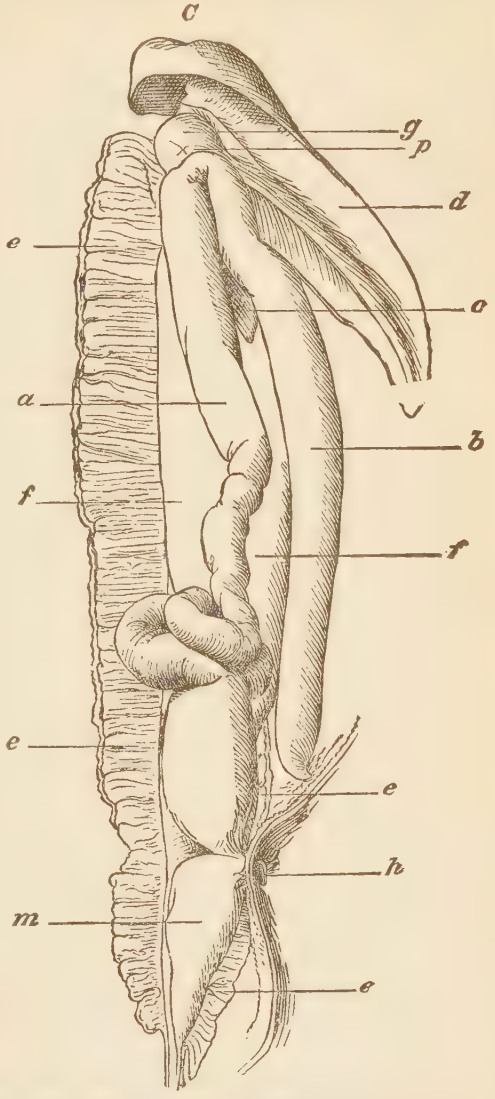
EXPLANATION OF FIGURE A, p. 126, AND B, p. 126.

A. Mature male reproductive organs of a specimen of *Conger vulgaris* 74cm long. One-half natural size; *a*, intestinal canal; *d'*, upper, *d''*, middle, *d'''*, lower portion of the liver, thrown over to left side; *f*, swimming-bladder; *g*, gall-bladder; *h*, anal opening; i_1, i_2, i_3, i_4, lobes of the left testicle; k_1, k_2, k_3, k_4, k_5, the five lobes of the right testicle; *l*, *bursa seminalis*; *m*, bladder; *p*, membranous border fringing the free edge of the testicle.

B. Spermatozoa.

* Ueber reife männliche Geschlechtstheile des Seeaals (*Conger vulgaris*) und einige Notizen über den männlichen Flussaal (*Anguilla vulgaris*). Von Dr. Otto Hermes, Director des Berliner Aquariums. Zoologischer Anzeiger, 1881, No. 74, pp. 39–44. Translated by J. A. Ryder.

The spermatozoa said to have been discovered in a male eel (*Anguilla bostoniensis*), according to Dr. A. S. Packard, jr.,* turned out to be an illusion. The announcement of this discovery was recalled in the *Zoologischer Anzeiger*, II, No. 26, p. 193, as follows: "The motile bodies were not spermatozoa but yolk particles." This correction was overlooked by Von Siebold's assistant, Dr. Paul,† as well as by S. Th. Cattie‡ of Arnheim, although the latter had read Jacoby's§ paper, in which, at page 44, the foregoing expression is mentioned, and which he himself has also cited in substance in the summary given by Jacoby.



EXPLANATION OF FIGURE C.

C. Undeveloped female reproductive organs of *Conger vulgaris* 84cm long. One-half natural size; *a*, stomach; *b*, cæcal appendix of stomach; *c*, spleen; *e*, right ovary; *e'*, left ovary; *f*, swimming-bladder; *g*, gall-bladder; *h*, anal opening; *m*, urinary bladder; *p*, base of the left ovary.

The reproductive organs of *Conger vulgaris* are very similar to those of *Anguilla vulgaris;* in the undeveloped condition they have the ovaries lying in the same position, in the form of a ruffle or frill-like band of relatively larger size. *Conger vulgaris* attains almost double the size of *Anguilla vulgaris;* examples measuring two meters (6 feet) are not uncommon. The ovaries also develop when the animal is in confinement, and I am convinced that this is often the cause of the death of the animal under such conditions. Upon opening some Conger eels

* Zoolog. Anzeiger, II, No. 18, p. 15.
† Oesterreichische Fischerei-Zeitung, 1880, No. 12, p. 90.
‡ Zoolog. Anzeiger, III, No. 57, p. 275.
§ Dr. L. Jacoby, Der Fischfang in der Lagune von Comacchio. Berlin, Hirschwald'sche Buchhandl., 1880.

which had died in the Berlin Aquarium, it was found that the ovaries were well developed, and a specimen which died in the aquarium in Frankfort burst in consequence of their extraordinary development. The weight of the ovaries of this animal, which weighed 22½ pounds, was 8 pounds and the number of eggs about 3,300,000. The absence in this case of the natural means by the help of which the animal could get rid of the eggs was apparently the cause of death. Male specimens of the Conger in an undeveloped condition I had not yet had an opportunity of examining. On this account, in the autumn of 1879, I obtained a number of Congers caught in the vicinity of Havre, the lengths of which would range from about 60 to 70 centimeters (or 2 to 2 feet 4 inches). These ate greedily and grew rapidly. But one individual was backward in its development; so that it was easily distinguished from the others. This specimen, the smallest in the aquarium, died on the 20th of June of the past year, and was examined by me on the same day. I was pleasantly surprised, as I found sexual organs very differently formed from those which I had always met with before. From a cut in the same a milky fluid escaped, which upon examination with a microscope enlarging 450 diameters, was found to contain a vast number of spermatozoa in the liveliest motion, which showed a head and tail very plainly. There was, therefore, no doubt about the fact that I had before me a sexually mature male of *Conger vulgaris*. Two portions of the milt or testes were cut off for the purpose of farther investigation, and the eel, 74 centimeters long, placed first in spirit, then in Wickersheimer's fluid. On the 24th of June, in company with Dr. Rabl-Rückhard, the anatomical discovery was confirmed.

The testes present to the eye the appearance of long, band-like compressed organs, attached along either side of the air-bladder by means of a fold of the mesentery, and extending the whole length of the abdominal cavity, and somewhat behind the vertical of the anal opening posteriorly. Each testicle ends in a tongue-like broader anterior and narrower posterior extremity, becoming thicker but narrower posteriorly, and is divided into a number of lobes of unequal size by a series of dorso-ventral emarginations. On the right side there are four emarginations and five lobes. The first of these measures longitudinally 45^{mm}, the second 70^{mm}, the third only partially distinguished from the fourth, 8^{mm}, the fourth 43^{mm}, the fifth 38^{mm}.

An exact enumeration of the lobes of the left testicle was not possible on account of the fact that a piece 5.5 centimeters had been removed for more extended study. The anterior part, including the space above named, is 98^{mm} long; then follows a lobe measuring 18^{mm}, and, lastly, a portion 80^{mm} long. The last is divided into three portions by two shallow oblique sulci, the portions measuring 15, 27, and 28^{mm} long, respectively.

The thickness of the above most developed left lobe was 9^{mm}, its breadth from its mesenteric attachment to its free border 18^{mm}. On the

left side the free tongue-like extremity of the testicle extends 12mm and on the right side 13mm beyond the attachment of the mesentery. The attachment of the mesentery begins on the right side 11mm farther forward than the left. The posterior extremity of the right testicle extends 4mm beyond the mesenteric attachment and 26mm beyond the vertical of the anus. The left testicle extends 38mm beyond the vertical of the anus, whilst its extremity scarcely extends beyond the mesenteric attachment. The free ventral border of both testes becomes gradually thinner, and forms a membranous border 4mm broad extending beyond the opaque parenchyma. This border is lobulated or crenulated owing to slight marginal incisions; it is very distinct at the anterior end of the left testicle, but is broader posteriorly where it is bent outwards, while at the same time it is more deeply notched or incised.

At the base of the testes lies the *canalis seminalis* or *vas deferens*, which opens into the *bursa seminalis;* and from the portion of testicle lying behind the vertical of the anus a similar canal leads to the *bursa seminalis*, from which the sperm is discharged through the *porus genitalis.*

If one compares this description and the figures* of the lobulated organ discovered by Syrski and called after him, there appears a striking similarity between the two. If it is borne in mind that in the first case we have to do with quite undeveloped and in the Conger with fully mature male reproductive organs, all doubts are put aside as to the sex indicated by the Syrskian organs. In the case of the *Conger* as in that of *Anguilla*, the fact remains, as upheld by Syrski, that the male is conspicuously smaller than the female.

As is well known, Von Siebold assumes that all the young eels which wander into streams develop into females, while the young males remain in the sea or at the mouths of the streams. This assumption should not be taken literally, however, for out of 250 eels caught in the vicinity of Cumlosen, measuring 28 to 42 centimeters, I found 13 males or 5 per cent. Cumlosen lies near Wittenberge, and is also not less than 25 miles distant from the mouth of the Elbe. What percentage of males is to be found nearer the mouth of the Elbe I have not been able to learn on account of a lack of material. Forty eels caught in the Havel at Havelberg were females without exception.

I found a remarkably large number of male eels in a lot of 137 caught in the bays joining the Baltic in the vicinity of Rügen, namely, 61 individuals or 44½ per cent., while amongst those taken at Wismar and the Danish coasts there was but 11 per cent.

Whether these facts have any relation or can give any clue to the position of the hitherto unknown spawning places of eels, it is hoped further investigation will show.

Although Cattie, in the paper already cited, gives it as an undoubted

*Abhandl. d. k. k. Akad. d. Wiss., April-Heft, 1874. The figure represents the liver of *Anguilla* as two-lobed. It has, however, a simple, tongue-like form, and is divided at its lower end into two lobules.

fact that eels migrate to the sea where in the course of six to eight weeks their sexual organs attain their full development when the old males as well as females die after having accomplished the reproductive act; there is no scientific ground, to the best of my knowledge, which would lend support to this assumption. What was considered as only probable by Von Siebold and Jacoby is, as it appears, assumed by Cattie to be proven.

Cattie further repeats Jacoby's suggestion, that perhaps as a consequence of an acquaintance with the experience of Günther referred to by Darwin, that in almost all fishes the male is smaller than the female, it occurred to Syrski to investigate the smaller eels. This assertion is without foundation. Syrski was led to his discovery without having had any hints from others. In his paper cited above he remarks as follows upon this point: "So I selected for my investigations the smallest eels I could possibly find, reflecting as I did so upon the fact that in many species of the animal kingdom the male is smaller than the female." Syrski writes me complaining bitterly that any one should compare this clear expression with the former and regard it the same, and that he knew nothing of the views of Günther and Darwin, with which he was moreover made acquainted only through Jacoby's paper.

Finally, as regards the distinction of the male from the female eels by external characters, those sent me from the Schleswig coast during the month of November presented such great differences in their coloration that the sender, the Royal Fish Inspector Hinkelmann, could indicate beforehand the number of each sex.

The males were distinguished by a striking bronzy metallic luster, while the females of the same size were of an almost uniform dull steel-gray color. Amongst the males a number of examples were found measuring 45 centimeters long, while Syrski found none over 43 centimeters in length. In Comacchio Jacoby was so fortunate as to find a specimen 48 centimeters long.

OFFICIAL PAPERS RELATING TO THE PROPOSED INTERNATIONAL FISHERIES EXHIBITION AT EDINBURGH IN 1882.

DEPARTMENT OF STATE,
Washington, August 1, 1881.

SIR: I inclose herewith, for your information, a copy of a dispatch of the 15th ultimo, from the vice-consul at Leith, with the inclosures, relating to the international fisheries exhibition to be held at Edinburgh, in April next. Any remarks you may deem proper to make for the information of the vice-consul will be communicated to him.

I am, sir, your obedient servant,

ROBERT R. HITT,
Assistant Secretary.

SPENCER F. BAIRD, Esq.,
Secretary of the Smithsonian Institution, Washington.

No. 191.] CONSULATE OF THE UNITED STATES,
Leith, Scotland, July 15, 1881.

SIR: I have the honor to inclose two communications I have received regarding the international fisheries exhibition to be held in Edinburgh in the month of April next, and I shall be obliged by your furnishing me with the information asked for in the circular by the exhibition committee.

I have the honor to be, sir, your most obedient servant,

A. McCASKIE,
United States Vice-Consul.

The Hon. JAMES G. BLAINE,
Secretary of State, Washington, D. C.

[Inclosures.]

1. Circular by Archibald Young, commissioner of Scotch salmon fisheries, dated July 7, 1881.
2. Circular by the committee of the international fisheries exhibition, Edinburgh, dated July 7, 1881.

No. 1.

EDINBURGH, 22 ROYAL CIRCUS, *July* 7, 1881.

SIR: I beg to inclose a circular drawn up by me and approved by the joint committees of the town council, the Highland Society, and the Scottish Fisheries Improvement Association, who are making arrangements for holding an international fisheries exhibition in Edinburgh in April next.

That circular, as you will see, is intended for the heads of fisheries departments in foreign countries, and I shall be much obliged if you will kindly inform me who is at the head of the fisheries in the country which you represent, in order that I may send him one of the circulars.

I am, your obedient servant,

ARCH. YOUNG,
Commissioner of Scotch Fisheries.

No. 2.

INTERNATIONAL FISHERIES EXHIBITION,
Edinburgh, 22 Royal Circus, July 7, 1881.

SIR: We have the honor to inform you that an international fisheries exhibition will be held in Edinburgh in the month of April next.

The exhibition will be open to exhibitors from all countries, and is intended to include, as far as possible, objects illustrative of or connected with the fisheries of the world, such, for example, as models, drawings, and photographs of boats used in fishing and of steam-engines adapted for fishing-boats; models of fishing-boat harbors and of fishermen's

houses; nets, lines, and fishing-tackle of all kinds both for the sea and inland waters; piscicultural apparatus; live fish in tanks; collections of stuffed fish and aquatic birds; life-saving apparatus, fog-signals, and lights for fishing-boats; fresh fish, cured and tinned fish, and preparations for preserving fish; models of fish passes and ladders and other similar objects.

We shall esteem it a favor if you will bring under the notice of those engaged in, or connected with, the fisheries in your country the fact that such an exhibition will be held there in April next; and if you will also kindly inform us whether you are likely to send us many contributions.

An answer to the above may be sent to Archibald Young, esq., commissioner of Scotch salmon fisheries, 22 Royal Circus, Edinburgh.

We have the honor to be, your obedient servants,

Sir I. R. S. MAITLAND,
Barrister,
WM. SKINNER,
City Clerk, Edinburgh,
F. N. MENZIES,
Secretary to Highland Society,
ARCHIBALD YOUNG,
Advocate, Commissioner of Scotch Salmon Fisheries,
Honorable Secretaries to International Fisheries Exhibition, Edinburgh.

NOTES ON THE MACKEREL FISHERY OF 1881.

By CAPTAIN S. J. MARTIN.

GLOUCESTER, MASS., *July* 26, 1881.

DEAR PROFESSOR: There appears to be a new school of mackerel on the coast. The vessels had lost the mackerel and could not find them. For a week they did not get many. The mackerel that were here were inshore, in shoal water. To use the seine, some of the vessels went offshore as far as Cash's Pound. There were plenty of mackerel ten days ago. They were driven to within 5 miles of the shore. For the last two days there have been plenty of mackerel 5 miles off Thatcher's Island. The last fish are of better quality. Three-fourths of the mackerel packed yesterday were No. 2. There were a very few large ones among them. The vessels are doing well. Yesterday there were 13 sail of vessels, with 3,500 barrels. To-day there were 11 sail, with 2,960 barrels. One vessel was out a week and caught 400 barrels. One vessel is in from Block Island with 100 barrels of large mackerel. The schooner Edward Webster is in from Block Island with 90 barrels of large mackerel. The schooner Ossipee is in from the bay of Saint Lawrence and reports no mackerel; that is good news for the fishermen. The prices of the fish are as follows: They were sold to-day at $4 a barrel with the barrel; mackerel packed sold for $5.50 a barrel for No. 2; $3.50 for No. 3.

Barrels to-day are worth $1.10 apiece. The inspection this year is $1.60 a barrel. If mackerel hold plenty, barrels will be worth $1.25 apiece in a week. The George's fishing fleet report plenty of mackerel on George's. Yesterday there were 50 sail of vessels at the wharves landing fish and mackerel. This morning there were 45 sail, mostly mackerel catchers, in the harbors for shelter. There was a fresh breeze, with rain, thunder, and lightning.

Your obedient servant,

S. J. MARTIN.

Prof. SPENCER F. BAIRD,
United States Commission Fish and Fisheries,
Wood's Holl, Barnstable County, Massachusetts.

NOTES ON NEW ENGLAND FISHERIES.

By S. J. MARTIN.

[From a letter to Prof. S. F. Baird, United States Fish Commissioner.]

GLOUCESTER, MASS., *August* 8, 1881.

DEAR PROFESSOR: The harbor this morning is alive with schooling mackerel, and 20 barrels of good quality, mostly twos and a few ones, were taken in the nets last night. The boys have great sport catching mackerel off the wharves. Bluefish are plenty off the mouth of the harbor, and I think they drove the mackerel in. There are some squid in the harbor.

The mackerel catchers have not done well during the last fortnight. The weather has been so foggy that they had to lie in the harbors eight days. Close to the shore the fog is not so thick, and here all the mackerel that have been caught were taken. Mackerel are found from Cape Cod to Mount Desert. There are 1,800 barrels of them on board vessels in the harbor this morning. The schooner Fleet Wing has 80 barrels of very large Block Island mackerel, worth $25 a barrel. Mackerel sold to-day at the low figure of $4 a barrel, with the barrel.

A new school of codfish has come on the western part of George's. The fish are the largest I have ever seen at this time of the year. I think they are a squid school, for when a fish is hauled up three or four squid will be found in it. Squid are plenty in Barnstable Bay. One vessel took 16 barrels there. A vessel came in from George's with 1,100 cod, which weighed 18,000 pounds split. The vessel which took 16 barrels of squid caught 21,000 pounds of cod in four days on the western part of George's. Some vessels have taken good trips on the eastern part of George's. The fish, however, are not so large.

I am glad some one has gone into the dogfish business. A steamer and a schooner are catching them at Booth Bay, Maine, and selling them to the factory at $1 a hundred fish. Dogfish are very plenty all along the coast. Some vessels come in with the whole bottom eaten out of the seine and the pocket.

MORTALITY OF M'CLOUD RIVER SALMON IN 1881.

By LIVINGSTON STONE.

[Extracted from letters dated July 10 and 12, 1881.]

The McCloud River salmon are dying in vast quantities from some unknown cause. The affected fish have this peculiarity, namely, that they appear on the exterior to be perfectly healthy fish. There are no parasites in the gills, no fungus on the bodies, no emaciation or any mark whatever on the outside to distinguish them from perfectly healthy fish. I secured and dissected one a day or two ago. The inside of the mouth and the gills seemed perfectly healthy and normal; the heart and liver seemed nearly as usual, but the alimentary canal and stomach were very much congested with extremely dark blood. You remember, without doubt, the small organ, of a deep red color, that lies at the lower extremity of the pyloric appendages. In the fish that I examined this organ was of an abnormal size, being three times as large, perhaps four times as large, as in a healthy fish, and of a dark, unwholesome color. I should say that this extraordinary enlargement of the spleen (as we call the organ here) was a sufficient cause for death. I will examine more as soon as I can get some.

THE FISH-EATING COWS OF PROVINCETOWN, MASSACHUSETTS.

By ISAAC HINCKLEY.

[Extract from a letter dated July 20, 1881.]

Captain Atwood has kindly given me facts in respect to fish-eating cows. Prior to the passage of the Massachusetts statute forbidding owners of cows to allow them to roam at will (which statute was enacted to protect directly the beach-grass which checked the drifting of sand), the cows flocked to the shore while the fishermen were cleaning their catch. These cows sought with avidity the entrails and swallowed them. They seemed willing to eat the heads also, but lacked the ability to reduce their bulk sufficiently to allow of this. A species of ling or blenny, weighing three pounds or more, and discarded by the fishermen, was freely eaten also by the cows. Cows when first arriving at Provincetown from the rural districts refused fish; but their owners, by adding minced fish to their cows' rations, soon taught the cows to imitate their neighbors in respect to eating entrails.

At this time the thirty-three cows, constituting the whole of Provincetown's stock, being "kept up," have forgotten or never learned the fish-eating practice.

DEVELOPMENT OF THE SPANISH MACKEREL (CYBIUM MACULATUM).

By JOHN A. RYDER.

The mackerel-hatching operations at Mobjack Bay were conducted on board the steamer Lookout and at Bosman's Fish Guano Works, New Point Comfort, Va., from the 5th to the 13th of July, 1880. Spawn and milt were obtained in that vicinity from sixteen individuals; the number of males and females was about the same. These ova were subjected to as thorough and systematic an investigation as the limited time at our disposal permitted. Some time previously Mr. R. E. Earll had succeeded in taking some eggs in the vicinity of Crisfield which were successfully fertilized and which hatched out in the amazingly short period of twenty hours. In every case the eggs taken and cared for by my assistant, Mr. W. P. Sauerhoff, hatched in twenty-four hours; it is true that a few hatched somewhat sooner, but some left the egg-membrane even later. I attribute this difference in the times of hatching in the two cases to different methods of treatment of the ova or to a great difference in the temperature of the water. The eggs taken and fertilized at 4 o'clock p. m. were all hatched at the same hour the next day. This season's experience at Cherrystone showed that when the temperature of the water was unusually low it would require nearly thirty-six hours for the eggs to hatch, but the development was normal.

The hatching operations for the season of 1881 were conducted at Cherrystone Harbor, Northampton County, Virginia, in the earlier part of the season, by the crew of the steamer Fish Hawk, but were afterwards continued on Kimberley's wharf, under the direction of Col. Marshall McDonald, commissioner of fisheries of Virginia. It was not the good fortune, however, of the latter party, of which the writer was a member, to obtain as large a number of ova as they had been led to expect; this was in the main due to our inability to control the times of fishing with the pound nets, which were the sources whence our supplies of spawning fish were obtained; also in part to their distance from our hatching station, which, as our facilities for the prompt transportation of the crew of spawn-takers by water was inadequate during the latter part of the time we were engaged in our investigations, added not a little to the disadvantages under which the work was conducted. Add to this the fact that, although the number of ripe fish obtainable was probably sufficient for our experiments, it was learned that they seemed for the most part to discharge their spawn only in the evening or at night, the times when by far the larger proportion of ova were obtained. That this fish is nocturnal in its spawning habits was still further demonstrated by Colonel McDonald while on a visit to Tangier Sound, where the Spanish mackerel is taken at night in gill-nets, a mode of

fishing not practiced at Cherrystone; an abundance of spawners, it was found, were taken under the above conditions at the former place, and it was believed, from observations made at the time, that many millions of eggs might be obtained there in a single night. From this it appears that what is now needed to make the artificial incubation of the mackerel a success is to choose some point for our operations where the fishing is carried on at night or in the evening. In relation to this part of the subject the writer will forbear to say anything further, as its discussion rightfully belongs to Colonel McDonald, whose observation it is; but I have been informed by Professor McCloskie, of Princeton, that while he was in company with Mr. J. S. Kingsley, during the present summer, on the Massachusetts coast, in the vicinity of Cape Ann, the latter gentleman conducted some observations on floating fish eggs which were taken at night in a tow-net and believed to have been laid after sundown; they were not identified, however. Ova which were found floating at the surface of the sea by Professor Haeckel,* at Ajaccio, off the island of Corsica, and afterward at Nice, were agglutinated together in clumps, but the species was not determined, and it was only supposed that they belonged to some gadoid, and are hence doubtfully referred to *Motella*. Edward Van Beneden† also, who describes at some length similar adhesive floating ova, which he had obtained in the same way, with the help of the tow-net, off Villafranca, does not identify them, nor does he state definitely at what time of day it was supposed they were spawned, but from the evidence afforded by his time record of the rate of their segmentation I am, nevertheless, prepared to believe that they were laid at night. The Cyprinodonts in the spawning season, as far as my observations go, are much more actively engaged in amatory play in the night than at other times, judging from the rapid motions and splashing noise which they make in the water during this part of the day. G. O. Sars, in his account of the development of the cod, says nothing in regard to the time of day at which this fish parts with its ova, but the writer believes that there are strong grounds for a belief that the bonito, or crab-eater (*Elacate canadus*), is a nocturnal spawner, the same as the mackerel, from the circumstance that it was only from individuals caught in the evening that ova were obtained, which appears to be the case also, judging from our experience, with the moon-fish (*Parephippus faber*). The foregoing data, although not all of them directly bearing upon the question of the time at which the Spanish mackerel discharges its spawn, are sufficiently within the scope of the evidence needed to help us to reach a conclusion in regard to the matter so that we will know how to proceed in the future. The artificial incubation does not appear to be the gravest part of the problem to be solved; the

*Die Gastrula und die Eifurchung der Thiere. Jenäische Zeitsch., IX, 402-508, 1875, 7 pls.

†A contribution to the history of the embryonic development of the Teleosteans. Quar. Journ. Mic. Sci., No. LXIX, 41-57, 1 pl., 1878.

question seems to be, under what conditions can the greatest number of eggs be obtained? Given a sufficient quantity of these, although the losses in hatching may be as much as 50 to 75 per cent., the number of young which it is possible to add to those hatched out naturally will still be prodigious.

OVARIES AND OVARIAN EGGS OF THE SPANISH MACKEREL.

The ovary of this fish is a paired organ composed of two nearly cylindrical sacks lying in the hinder upper portion of the abdominal cavity; both taper to blunt conical points anteriorly, and are joined posteriorly into a wide common ovarian duct, which opens just behind the vent. Attached to the walls of the ovarian sacks are a vast number of ovarian leaflets or folds placed transversely, and which depend directly into the space within the sacks. In these leaflets the ovarian eggs are developed, each one in a minute sack or follicle of its own, the walls of which are richly supplied with capillary blood-vessels joined to the blood system of the parent fish. At first the ova are very small, but as the season advances they, for the most part, increase in size, in consequence of which the entire ovary increases in bulk. At first, when they begin to grow larger, they are barely distinguishable from the ordinary cells which compose the great proportion of the tissue of the ovary; they are in fact nothing more than greatly enlarged cells when mature, in which we may distinguish an outer germinal layer or pellicle, *gp*, Fig. 2, covering a store of nutritive material known as the yelk, which is gradually absorbed as development progresses; besides, they are covered by an egg-membrane, *zr*, of extreme thinness, perforated at one point only by a minute pore known as the micropyle, which is shown in two positions in the same egg in Fig. 1, lying in the center of a circular area which has faint markings running out radially from the micropylar pore in its middle toward its margin. The micropyle is funnel-shaped and the radial markings and area around it seem to disappear almost entirely after impregnation. The egg-membrane may be regarded merely as a protective covering and the micropyle as a passage-way for the male element or spermatozoan to find its way through the egg-membrane and to the germ, in order that impregnation may take place, when the development or growth of the embryo fish will commence. The opening also connects the space inside the egg-membrane between the latter and the globular egg or germinal mass with the water outside in which the egg floats; the space here alluded to does not usually appear until immediately after impregnation, in consequence of which the egg-membrane at first lies laxly on the germ within, and in the eggs of some species, as in the shad, it is at first considerably wrinkled. It is only after impregnation that it normally absorbs water through the micropyle and becomes tense and perfectly globular. The history of the formation of the egg-membrane is not very clearly established, but it appears in

the highest degree probable that it is secreted from the cellular walls of the sack or follicle in which the egg grows and is matured.

The youngest ova of the mackerel do not appear to be inclosed in independent follicles; these seem to be developed only after the egg has attained some dimensions. Very young ova are found to contain a relatively large nucleus or germinative vesicle inclosed in a thin layer of transparent homogeneous protoplasm, and for a considerable time this condition seems to be maintained, but as they increase in size it is found that, while the germinative vesicle increases in dimensions, the protoplasmic envelope also grows in thickness, and that there is a tendency to multiply the number of nucleoli or germinative spots included in the germinative vesicle. At a still later period the nucleus becomes apparently granular, and finally, when the egg is mature and ready to rupture the follicle in which it grew, the germinative vesicle, as well as the spots, seem to have disappeared; at any rate it is now generally held that when the egg has attained maturity the germinative vesicle undergoes disintegration, and perhaps a reorganization, by which a portion of it becomes what is known in recent years as the female pronucleus, which conjugates or becomes fused with a similar body called the male pronucleus, which results from the metamorphosis of the head of the male element, or spermatozoan, after its entry into the germinal matter of the egg. It is this body, made up, as it is, in part of male and in part of female or ovarian protoplasm, which constitutes the nucleus of the first segmentation furrow across the germinal disk in which it is embedded, and which must be regarded as the initial or starting point in the development of the young fish. It is also doubtless a fact that during the process of division of the germinal disk we would find the nuclei elongated with granular rays extending from their ends through the surrounding protoplasm, as well as bands or fibrils of denser protoplasm running from one end to the other of the nuclear figure. When the cleavage is completed the rays and bands appear to be withdrawn, and each pole of the formerly elongated nucleus becomes rounded independent of its fellow, and so two nuclei result, the dynamic or force centers of two cells, the products of this process of cleavage of the original cell. This process has been named *karyokinesis* by Prof. W. Flemming, of Kiel, in allusion to the apparent exhibition of the modes of motion of the matter of the life centers of cells. Nuclear figures of great complexity, but always bipolar during cleavage, have been described by this author and others in both animal and vegetable tissues. That they exist and will be found well developed in the very early stages of the cleavage of the germinal disk of the embryo fish, I have not the slightest doubt; it will depend upon the method of demonstration as to whether or not they will be made visible. My reason for this statement is the fact that the early stages of the segmentation of the germinal disk of all the species of fish ova which I have observed closely enough are essentially rhythmical; that is to say,

between the periods when a given set of cells divide there is a longer interval of repose or rest, which may even in some cases be accompanied by a slight subsidence or depression of the cells which have just divided. Brooks speaks of it in the mollusks as a contraction of the resulting cells. It seems to me, from what I have seen in the segmenting eggs of *Mya* and *Alosa*, that the term "subsidence" is more directly applicable, since in the act of segmentation the protoplasm appears to have a tendency to become rounded or heaped up in the two new cells, and that afterwards or during the period of rest the protoplasm has a tendency to subside or spread out, as a result of which the segmentation furrows become much shallower. Brooks* has noticed these phenomena in ova supposed to be those of the toad fish (*Batrachus tau*), and alludes to observations in other forms by E. B. Wilson and S. F. Clarke. What first attracted my attention to the matter was the fact that, while ova in the early stages of development were under observation, I was frequently surprised to find, after having left the microscope for a few minutes, that a sudden and rapid change had taken place, while no change whatever was observed previously for the space of an hour or more. Brooks has kept a time record, which I neglected to do, but I can say, however, that in the shad egg, in which I have mostly observed this phenomenon, the intervals of rest are of much shorter duration than recorded by him, showing that he dealt with an egg which developed more slowly. In the mackerel ovum, in which I have had but little chance to observe these phenomena, the intervals of rest are of less duration still, but inasmuch as it develops with three times the rapidity of the shad egg, it is plain that it would be an admirable subject for investigation in respect to this point, and in which microphotography would be an invaluable aid.

The early stages of segmentation of the mackerel, studied by the writer, unless observed with the microscope, on an unsteady boat, where such observation is almost, if not altogether impossible, were usually too far advanced to keep track of the sets of dividing cells, which were already too numerous, so that they would confuse the student in his attempt to follow the changes marked by intervals of rest between periods of activity. The writer, however, must admit that he has never been able to distinguish the nuclei of the cells as clearly without reagents as figured by Brooks, although working with the most approved apparatus for obliquity of illumination, and with lenses of fine definition; but this may be due to the fact that different species were studied by us.

STRUCTURE OF THE TESTES AND GENESIS OF THE SPERMATOZOA.

The testes of the Spanish mackerel are paired organs, like the roe or ovaries of the female, and have much the same position in the abdom-

*Alternations of Periods of Rest with Periods of Activity in the segmenting eggs of Vertebrates. Studies Biolog. Laboratory, Johns Hopkins University, Vol. II, 117–118, 1 pl., June, 1881.

inal cavity, but are much flattened or compressed laterally, instead of cylindrical, as in the former, and both pour their secretion through a wide seminal duct which opens behind the vent. Their substance is composed almost entirely of a vast number of minute canals, which have a generally vertical or oblique direction, and which open into a wide sinus or space at the upper edge of the organs, and which empty their contents into the common seminal duct. They are essentially glandular in function, and secrete and pour out large quantities of milt or semen during the spawning season, which is developed in the tubules or canals already alluded to. These canals, or, more properly, seminiferous tubules, are lined with cells, which break up into bundles of spermatozoa, which fall directly into their cavities, and so find their way into the seminal sinus at the upper border of the testicle and out through the seminal duct into the water, where they are capable, if they come into contact with the ova discharged by the female, of effecting impregnation and of establishing the development of the embryos. The spermatic particles, or spermatozoa, are themselves very minute, and are composed, in the mackerel, of an oval head with a very fine, almost ultra-microscopic, tail or flagellum, which is incessantly lashed about in the living state, so that the spermatozoan has a distinctive wriggling, tadpole-like movement. As soon as the power to move the lash or flagellum ceases, they may be considered as dead, and no longer capable of effecting the impregnation of ova. They will not ordinarily live much over an hour after being taken from the fish, with which time their effectiveness ceases.

STRUCTURE AND PHYSIOLOGICAL CHARACTERISTICS OF THE UNFERTILIZED EGG OF THE SPANISH MACKEREL.

It is notorious that the egg-membranes of floating fish ova are extremely thin; moreover, they are not, as far as I have been able to make out with carefully conducted observations, perforated by pore-canals, as in the stickleback, salmon, and shad; the membrane of the ovum of the mackerel is no exception to this rule, and is consequently not a *zona radiata*, as defined by Balfour. It is a perfectly homogeneous, transparent film, less than half as thick as that covering the shad ovum, which measures approximately $\frac{1}{320}$ of an inch in thickness, but differs from the latter in having minute papular prominences on the inner surface which project into the breathing chamber or water space around the germ, as shown in Figs. 2, 6, 9, and 12. These prominences usually seem to be confined to one pole or hemisphere of the membranous envelope.

The ova vary slightly in dimensions and range from $\frac{1}{25}$ to $\frac{1}{20}$ of an inch in diameter. This variation in size is a usual feature in the ova of fishes, but may be partly due to the unusual pressure exerted on the ovaries when the ova are removed artificially, so that some are squeezed from their follicles before they are quite fully mature, though it is to be remarked that the smaller ova develop just as readily as the larger

ones, and every one is aware of the fact that the eggs of the same birds vary considerably in size, and that such variation does not interfere perceptibly with their capability to develop. Between the egg-membrane and the germ or vitellus there is always a more or less well marked space or cavity filled with water which has been absorbed from without, as is proved by the fact that when the ova are at first extruded the egg-membrane, in all the species studied by the writer, is more or less relaxed or even wrinkled, and that it is only after they have been in water for some time in the presence of spermatozoa that the membrane will distend so as to render it tense and spherical. Unimpregnated eggs which have absorbed water are said to be "water-swollen," and usually only a small percentage of them will become so in the absence of living spermatozoa, mixed with them in the water. Ova which have been impregnated and are water-swollen, that is, have developed the water space around the vitellus, are said to have "risen," which is probably in allusion to the fact that in some cases—minnows and shad—a lot of newly laid ova will by this process acquire several times their original bulk, so that if too large a quantity of freshly spawned eggs be put in a vessel the mass will swell in the presence of water so as to fill the receptacle or even run over its sides, somewhat in the same way as leavened dough would acquire increased bulk in a dough tray by the numerous vesicles of carbonic dioxide which are evolved by fermentation and held in confinement by the tough mass of gluten and starch. The water space may in some cases embrace more than two-thirds of the solid contents of the sphere included by the egg-membrane, but this space is smaller and is never at any time more than the $\frac{1}{250}$ of an inch in vertical thickness in the egg of the mackerel.

Its function is, doubtless, in the main, respiratory, as suggested by Ransom, who has actually named it the *breathing chamber*, and it would seem that there is very strong evidence in favor of such an opinion, in that most fish ova die if the water in which they are hatching is not frequently changed. The circumstance that some fish ova are fixed by filaments or by an adhesive material while the water moves over them on account of its gravity or in consequence of tidal action, would seem to indicate that these modifications were favorable to their aeration, or perhaps, more properly, their respiration, and exchange of salutary oxygen for hurtful gases through the membranous and fluid coverings of the egg. The habit which the male stickleback appears to have of pumping water through the nest with his mouth, so as to change the water surrounding the eggs in his charge, seems to be similarly significant.

This cavity serves another purpose. In it the young fish may develop immersed in fluid free from friction or hurtful knocks from without, if it is a free swimming egg, like that of the mackerel. Its function, aside from that of respiration, would then appear to be essentially that of an amnion, or "bag of waters," such as is developed from the

edges of the germinal disk in reptiles, birds, and mammals, and which eventually incloses the embryos of these forms, and in which they undergo the largest part of their development. A similar spacious cavity appears to exist in the egg-cases of the oviparous sharks, and rays, filled with water or a thin serous fluid, in which the embryo develops as it absorbs the contents of the yolk sack. The same remark applies to the eggs of the Amphibia and *Amphioxus;* so it appears that all of the vertebrates below the reptiles have an egg-membrane, or what answers to it, and a water or respiratory space in which the germ or vitellus is included, and in which it undergoes a more or less complete development.

The vitellus or germ included by the egg-membrane of the mackerel is globular and very nearly fills up the cavity, bounded by the membrane, so that the water space or breathing chamber is small. The vitellus is made up of three principal portions: a thin outer germinal layer, as shown in Fig. 2, which incloses a globular yolk-mass, in which it is ordinarily difficult to distinguish the contour of the yolk spheres of which it is composed. Imbedded in this yolk-mass there is always a single oil sphere perfectly globular, highly refringent, and measuring about one one-hundredth of an inch in diameter, and which always occupies an eccentric position in the upper hemisphere of the living egg. It is the presence of this oil sphere which causes the egg to float; the drop of oil is always in such a position as to keep the developing embryo inverted or turned upon its back. This is probably due to a purely physical cause; the oil sphere, being the lightest part of the egg, will always be found in its upper hemisphere, while the germinal disk or embryo appears to be the heaviest part, and in consequence is always found in the lowermost hemisphere looking back downwards. It is difficult to trace any protoplasmic filaments passing off from the germinal layer of the mackerel's ovum down amongst the yolk spheres, in consequence of which it is difficult to demonstrate the latter. It has likewise not been my good fortune to trace and learn what is the fate of the germinative vesicle of the mackerel egg, but it will suffice to say that when the egg is mature it can no longer be distinguished; nothing whatever remains to indicate its former position, and the whole egg is now more transparent and presents the appearance shown in Fig. 2. The germinal layer or pellicle, however, is found to include a great number of very minute refringent corpuscles scattered through its substance; these disappear as the germinal disk is formed by the aggregation of the protoplasm of the germinal layer at one pole of the vitellus to form the germinal disk. I have frequently seen them apparently dissolve and disappear while I was observing them through the microscope. Whether these represent the remains of the more fluid and refringent germinative vesicles I am unable to say, but I am inclined to doubt it from the fact that if the germinal pellicle is removed and stained with haematoxylon these corpuscles do not tinge, while the pro-

toplasm in which they are imbedded does, which appears to be a sufficient proof that they are not the remains of the germinative vesicle, but that they are merely vacuoles filled with fluid, such as are found in the Protozoa, but which, unlike the spaces found in those animals, are not rhythmically contractile or pulsatile.

ORIGIN AND FORMATION OF THE GERMINAL DISK.

The germinal disk of the egg of the mackerel measures one-fortieth to one-fiftieth of an inch in diameter, is biscuit-shaped, and is composed of a light, amber-tinted protoplasm several shades darker than the protoplasm which makes up the vitellus, which is remarkable for its glass-like transparency. Normally, the disk always lies directly at one side and apparently on the surface of the yelk, as indicated in Fig. 4; and when the egg is in the water it is always immediately and exactly below the latter. The disk may be developed independently of impregnation, but in that case an embryo is never formed, and the egg soon disorganizes, the vitellus collapses, and the whole protoplasmic mass, disk and all, acquires a brownish, granular appearance, indicative of death and disorganization. The disk takes its origin directly from the germinal pellicle, which incloses the vitellus just like the rind which covers the flesh of an orange. This layer at first thickens at one side, and its substance seems to flow gradually to the lower pole of the egg till the resulting disk acquires the shape of a concavo-convex lens, with a thin, sharp rim. Eventually the sharp rim disappears, it becomes smoothly rounded at the edge, and the whole disk biscuit-shaped.

It is probable that an extremely thin layer of protoplasm, which originally formed part of the germinal pellicle or layer, still covers the vitellus, and is continuous with the disk, and is synonymous with the intermediary layer described by Van Bambeke and E. Van Beneden. My reason for this statement is the fact that the disk is sometimes found to have a thin layer of protoplasm extended outwards below its thick rim over the vitellus, but which becomes so thin a little way out from the edge of the disk that it becomes impossible to demonstrate it without special methods. That the vitellus is covered by a structureless membrane is proved by the fact that in the event of its being ruptured its glairy contents will very rapidly escape, and its torn edges can be seen limiting the opening or rent in its walls. The segmentation of the thicker part of this membrane of protoplasm next the disk is shown in Fig. 4, and is also described at considerable length by Van Beneden in the paper already referred to in a foot-note. In the crab-eater (*Elacate*) a very peculiar wreath of flat cells is developed at the edge of the disk, which, as in the ova of the supposed gadoid studied by Van Beneden, appear to be continuous, with a layer of small cells below the thicker lens-shaped part of the germinal disk.

It may be well to retain the term *intermediary layer* for this structure, but if the distinguished Belgian embryologist had succeeded in follow-

ing the development of the ova which he studied a little farther along, he would have learned, as he indeed surmises, that the wreath of cells becomes the thickened rim of the blastoderm, and that the portion of the intermediary layer beneath the disk becomes the hypoblast. I see no reason, however, for adopting the term *blastodisc* for the germinal disk of the fish egg, for the whole of the latter, as well as the intermediary layer, are both unquestionably derived from the primitive peripheral germinal layer, the existence of which has been fully illustrated and described in the herring ovum by Kupffer,* though Coste† describes the formation of the germ in language which shows that he had undoubtedly seen and watched the process, which differs in different species, as we shall learn when we come to discuss them. I reproduce Coste's words below.‡ Kupffer describes the process minutely in the herring, but states that the germ is never formed independently of the action of the spermatozoan in that species, which is practically the fact in the case of the shad and cod, but is not the case in *Parephippus*, *Chirostoma*, and *Ceratacanthus*, where a germinal disk is formed independently of impregnation, but not until some time after the egg is laid. Even in the three last-named species the process of the development of the disk is the same, viz, the peripheral layer of germinal protoplasm aggregates at one pole of the vitellus. In some species, as in the herring, shad, crab-eater, and stickleback, strands of protoplasm pass inwards from the germinal layer among the yelk spheres or corpuscles of the vitellus, so as to involve the latter in a sort of meshwork, which, after the disk is formed, trend toward the center of the latter, forming a protoplasmic mass below the disk, and continuous with it, which probably fills a space in the yelk below the disk, and which Kupffer calls the "latebra" and Van Beneden the "lentille." Upon close examination, however, these structures seem to me to be nothing but a portion of the germinal disk, in consequence of their connection with the intermediary layer lying between the latter and the vitelline globe or yelk. The failure of more observers to witness the mode of development of the germinal disk, and the fact that some have actually figured the segmentation cavity without knowing what it was, is only explicable from

* Die Entwickelung des Herings im Ei, in Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel. 4to, Berlin, 1878, p. 181.

† Origine de la cicatricule ou du germe des poissons osseux. Comptes rendus, tome 30, 1850, p. 692.

‡ "Ses éléments générateurs restent épars, disséminés dans tous les points de ce vitellus, jusqu'au moment où l'action du mâle les détermine à se précipiter vers une région de la surface où on les voit tous se réunir pour constituer le disque granuleux que la segmentation organise plus tard."

"Quand cette curieuse *émigration* des granules moléculaires que doivent former la cicatricule s'est opérée, l'œuf des poissons osseux ressemble alors, mais alors seulement, à celui des oiseaux."

The writer, in explaining the formation of the germinal disk, is in the habit of describing it as an *amœboid migration* of the germinal matter toward one point on the vitellus, which is essentially the meaning of this quotation; but the germinal matter is not always mixed among the vitelline corpuscles, as Coste describes in *Gasterosteus*. It is the case in *Clupea* and *Alosa*, but not in *Gadus*, *Cybium*, or *Belone*.

the fact that most of the naturalists who have made the study of fish embryos a specialty have had the ill fortune to have the chance to watch only a part of the developmental stages.

THE IMPREGNATION OF THE EGG.

Upon this subject there are very few reliable observations. As Axel Boeck truly remarks, the micropyle is often difficult to find; and what makes the matter still more troublesome is the size of the egg, which makes it necessary to use lenses of long working distance, and to amplify with high power eye-pieces. To get an egg into position is not unfrequently a difficult performance, and by the time everything is arranged for observation impregnation has been effected and your efforts are wasted. It is doubtless correct to say that a single spermatozoan is effective in the fertilization of an egg. I have frequently found a number of dead ones sticking fast by their heads to the egg-membrane near the micropyle, but I have never witnessed their actual entry, although I have frequently made attempts to see the phenomenon, but so far without success. From all that we can learn it is undoubtedly true that the presence of spermatozoa with freshly laid unimpregnated ova at once tends to cause them to absorb water, as is well known to every practical spawn-taker. That their presence in the egg exerts a great influence on the rapid formation of the germinal disk in the herring, shad, and cod is equally certain. What the exact nature of the changes may be that are first of all induced by the presence of the spermatozoan in the egg of the Teleostean fish, we are not yet prepared to say. Most if not all the most satisfactory observations upon the phenomena of impregnation have been conducted on the very much more minute ova of invertebrates, where it has evidently been much easier to see the process and follow it in detail. Its effects are soon visible, however, as the remarkable phenomenon of segmentation which begins soon after fertilization has been effected.

SEGMENTATION OF THE GERMINAL DISK.

The segmentation of the germinal disk of the mackerel is essentially similar to that of the cod. The first cleavage is transverse, resulting in two cells. The next segmentation is at right angles to the first, and, when completed, divides the two cells of the first cleavage into four; the next cleavage is in a direction at right angles to the last and results in the formation of eight cells. Beyond this point the cleavage becomes more or less irregular, except that the germinal disk remains for a considerable time composed of a single stratum of cells, as shown in Fig. 3, one hour and forty minutes after impregnation. The rhythmical nature of the process of segmentation up to this time has already been alluded to, and it no doubt continues, but the cells soon become too small to be followed up so as to observe the intervals of rest and activ-

ity. At the end of three hours the germinal disk, as shown in Fig. 4, has undergone profound changes; the cells are no longer arranged in a single stratum, but in several, superimposed upon each other, which has been the result of the segmentation of the cells of the morula stage of Fig. 3 in a plane parallel to that of the great diameter of the disk. At the same time there has been a wreath of flat cells segmented off from the edge of the disk, which would be considered by some as originating separately or independently of the disk, an opinion from which I dissent for reasons which I have already stated in dealing with the origin of the disk from a primitively homogeneous, external germinal layer of protoplasm.

THE BLASTODERM AND SEGMENTATION CAVITY.

In Figs. 5 and 6, a half hour later, we see that the fate of the marginal cells has been to form the rim of the incipient blastoderm, which is beginning to spread out, become thinner, and lose its distinctive features as a biscuit-shaped germinal disk. The inner edge of the rim of cells just alluded to limits the margin of the segmentation cavity of the mackerel egg, and I can see no reason why this space should not be considered homologous with the cavity which bears the same name in the blastoderm of the embryo elasmobranch and chick, in both of which it is probably of greater extent than it has been hitherto suspected. The roof of the cavity is at first two or three or even more cells deep, but as soon as the rudiment of the embryo fish is defined at the edge of the blastoderm its roof soon after is found to be composed of but a single layer of cells, corresponding to the epiblast or skin layer, while its floor is the *intermediary layer* of Van Bambeke, and corresponds to the hypoblast, mucous or deepest layer from which the intestine, the blood for the most part and perhaps the notochord is derived as development advances. With slight verbal alterations I will here quote from what the writer has published elsewhere*: "The disk begins to spread over the vitellus or yelk, and soon acquires the form of a watch glass, with its concave side lying next the surface of the yelk. Coincident with the lateral expansion of the disk, now become the blastoderm, a thickening appears at one point in its margin, which is the first sign of the appearance of the embryo fish. With its farther expansion the embryo is developed more from the margin of the disk towards it center; in this way it happens that the axis of the embryo lies in one of the radii of the blastoderm, its head directed towards the center, its tail lying at the margin" and continuous with the rim, which is soon two or three cells thick, and extends all the way round the edge of the blastoderm like a ring. "Before the embryo is fairly formed a space appears in the blastoderm, limited by the thickened rim of the latter, and the embryo at

* Structure and ovarian incubation of the Top-minnow (Zygonectes), "Forest and Stream," August 18, 1881.

one side. This space, *the segmentation cavity, is filled with fluid and grows with the growth of the germinal disk, as the latter becomes converted into the blastoderm, and does not disappear until some time after the embryo has left the egg as a young fish*, after remaining as a *space* around the yelk-sack as long as a vestige of the latter remains, as may be seen in the young of *Cybium, Gadus, Elecate, Syngnathus*, and *Alosa*."

My observations have been conducted without hardening reagents, since it has been found that such methods abstract the water from the embryo, and cause the segmentation cavity to collapse and be obliterated, so that the only way in which the writer has been able to follow the history of this space was to study it in the living transparent eggs, which may be got into various positions so as to show all the phases of its development in the different stages of the evolution of the embryo. I believe it will be found to be present in the blastoderms of the ova of almost all teleostean fishes.

"Should this prove to be the fact [quoting from the same source] the teleostean egg will be as distinctly defined, in respect to the sum of the developmental characters which it presents, from the developing ova of other vertebrates, as the adult teleost is from the remaining classes of the subkingdom to which it belongs."

Later, as is shown in Fig. 7, or after seven hours, the blastoderm has grown so as to inclose nearly one-half of the vitelline globe or yelk, the rim is very distinct, and when viewed from above as a transparent object, the segmentation cavity is visible as a somewhat crescent-shaped area more transparent than the embryo or the rim. The embryo bounds the concave side of the crescent and lies in immediate contact with the yelk, except over a small space just under the fore part of the head, which is found to be continuous with the segmentation cavity beneath the latter; this space will be found to be very significant, and is the cavity in which the heart develops. In taking another look at Fig. 7, it will be noticed that the blastoderm is a hemispherical cap, and that on the left hand from its center to the edge of its rim there is a thicker portion shown; this is the embryo mackerel seen from the side with its head end lying in the middle of the disk and its tail at the edge. To the right hand and below a clear space is shown; this in like manner is the segmentation cavity seen from the side, and to the right of it the blastodermic walls are seen to be double, consisting internally of the hypoblast and externally of the epiblast, with a space, *sg*, between them; this is the segmentation cavity in optic section, which is seen to extend a little way under the head of the embryo at *crs*, to form the cavity in which the heart will be formed. To the left of *crs* the keel or carina, *cr*, of the embryo dips down into the vitellus; the carina is simply the fore part of the medullary canal, which for the most part becomes the great median nervous or spinal cord of the young fish; in all embryo teleost fishes it is much flattened laterally in its fore part, and in consequence it dips down far into the yelk as a flat

tube, for such it is from the fact that a furrow appears on the outer surface of the blastoderm known as the medullary groove which extends from the head end of the embryonic area of the blastoderm to the rim and which causes the blastoderm to be pushed down before it. This groove first closes at the head of the embryo, while it remains open for a considerable time at the tail end. The cells of its walls form the embryonic spinal canal which afterwards becomes the spinal cord, brain, and retina of the more advanced embryo.

Fig. 8 represents an older embryo Spanish mackerel, eleven hours after development began. It is seen with the head towards the observer, and behind or beyond the head on the opposite side of the egg the rim *r* of the blastoderm is seen through the transparent vitellus, which will close over the latter entirely in the course of another hour. The segmentation cavity *sg* is shown in optic section between the epiblast *ep* and the hypoblast *hy*, extending all round the egg except the portion taken up by the embryo above, and that part not yet covered by the blastodermic rim *r* on the opposite side of the egg.

Fig. 9 represents an egg of the twelfth hour of development with the caudal pole turned towards the observer. The small area *y* is all of the vitellus which now remains uncovered, and the blastodermic rim is contracting and will soon close at the end of the tail of the embryo, when the formation of the blastoderm may be said to be completed. The segmentation cavity *sg* has of course been somewhat extended on account of the approximate closure of the blastodermic rim. In Fig. 11 a section is carried transversely from left to right through the opening *y*, which still remains behind the tail of the embryo represented in Fig. 9, to show how the segmentation cavity is finally limited at the caudal end of the embryo by the blastodermic rim, which after its closure takes a large share in the formation of the tail of the young fish, as pointed out by Kupffer and His. It may be considered the true tail-swelling, as it thickens into a round, knob-like prominence immediately after the inclusion of the yelk is accomplished. In consequence of the remarkable extent of the segmentation cavity in fish embryos, as amply proved by our studies upon a number of widely-separated genera, the yelk becomes inclosed in a shut sack derived from and including the greater part of the innermost embryonic layer or hypoblast, which is surrounded by a film of fluid, and which is again inclosed by an external epiblastic sack. Besides the demonstration of this structure in the living egg I have used the following method with success: Immerse a living embryo in a one-half per cent. solution of osmic acid for a few minutes, or till the outer sack becomes light brownish, then place it under a Fol's compressor and gradually bring pressure to bear on the vitellus while it is under observation in the microscope, when the outer covering, now made brittle by the osmic acid, will rupture and expose the vitelline or hypoblastic sack; the epiblastic covering will frequently open, wrinkle, and slide back off of the vitellus like a cowl when pushed back off of the head.

It is this structure which Cuvier and Valenciennes* allude to in the following words: "Le vitellus a deux tuniques, complètes l'une et l'autre, quoique très-fines. L'externe se continue par sa lame extérieure avec le peau et par l'intérieure avec le peritoine; l'interne, très-vasculeuse, se continue avec les membranes des intestins et leur tunique péritonéale; la cavité donne directement et visiblement dans celle de l'intestin, et la matière du jaune y afflue." This quotation shows that Cuvier, to whom it is in all probability to be ascribed, was aware of the existence of a double envelope over the yelk, but in no instance have I found what could be considered a communication between the cavity of the intestine and the vitellus. Von Baer is stated by Balfour† to speak of two types of yelk-sack, one inclosed within the body wall, and the other forming a distinct naked ventral appendage of the embryo, from which it is clear that the great German embryologist never clearly understood the manner in which the vitelline globe or yelk is inclosed by the blastoderm. Nor can I confirm Lereboullet's view that a connection of the vitellus and cavity of the intestine exists between the stomach and liver, because the stomach is not ordinarily differentiated in young fishes while the yelk persists. In the young California salmon (*Oncorhynchus*) the muscle plates grow down on either side between the epiblast externally and the splanchnopleure internally. The hypoblast covering the remains of the yelk is traversed externally by a network of blood vessels, as may be learned from an examination of transverse sections through advanced embryos. In this way it results that the segmentation cavity is obliterated or filled up during the latter part of embryonic life by the down growth of the somatopleure and splanchnopleure between the epiblast and hypoblast, both the splanchnopleure and somatopleure having originated from the mesoblast. This, I believe, is essentially the mode of development of the blastoderm in teleostean embryos and the way in which the segmentation cavity disappears. Any view, however, according to which the yelk is looked upon as a mere nutritive vesicle, and not at all times in intimate organic union with the embryo, betrays a want of comprehension of the way in which the teleostean ovum is developed in the ovary, the manner of the formation of the germinal disk, the development of the blastoderm and inclusion by it of the vitellus, and, finally, of the relation of the heart and blood system to the vitellus.

STRUCTURES DEVELOPED IN THE EMBRYO MACKEREL FROM THE ELEVENTH HOUR TO THE TIME OF HATCHING.

Starting with the stage represented in Fig. 9, when the medullary canal *m*, in section, the notochord or cartilaginous axial rod *ch*, and the somites or muscle plates on either side of the medullary canal are developed, it is apparent that the embryo by the fourteenth hour, repre-

*Histoire Naturelle des poissons, tome i, p. 399. Paris, 1828.

†Comparative Embryology, vol. ii, p. 65.

sented in Fig. 10, begins to exhibit some likeness to an animal organism, but as yet the species would not be recognizable were it not known from what parent form the egg had been obtained, though it could undoubtedly be referred to the class *Pisces*, subclass *Teleostei*. A careful study, however, of a number of forms will enable the student to distinguish them apart at a very early period of development. The number of somites or muscle plates increases from before backwards; they first appear some distance behind the rudiments of the ear, *au* Fig. 8, and by the regular successive segmentation of the upper mesoblastic plates of cells on either side of the medullary canal increase in number backwards toward the tail, and by the time the caudal swelling is developed there are about twenty muscular somites or segments of the body. As the tail grows and is extended backwards the segmentation of the muscular stratum of the mesoblast continues in the same way from before backwards, but does not for a considerable time involve all of the structure destined to become the lateral muscular masses of the young fish; the portion at the end of the tail remaining unsegmented for some time after hatching. The muscular segments, somites, or protovertebræ, as they have been variously named, originate from the two tracts of mesoblastic tissue on either side of the medullary canal, and are really the rudiments of the muscular masses, the edible flesh portions found on either side of the backbone of adult fishes. They appear at first in the embryo as quadrate masses lying on either side of the medullary canal, and in embryo sharks, according to Balfour, and in the lampreys, according to Scott, at first are said to be hollow; in our studies we have not succeeded in demonstrating this peculiarity in teleostean embryos. They are nearly or quite solid in the latter.

Immediately after the tail swelling has been formed, the caudal rudiment forms a blunt rounded point, which, as it is prolonged backwards, develops a continuous median dorsal and ventral ridge or fold of epiblast, as shown in Fig. 12, and which becomes the natatory fold *nf* of Fig. 13, from which all the unpaired fins are developed. Almost as soon as the tail begins to grow out a strand of hypoblastic cells, *v*, Fig. 12, is seen on the lower side of it, lying between the epiblastic layers of the natatory fold, and extending to the edge of the latter; this strand of cells appears to have been probably continuous with the medullary canal or cord on the dorsal side of the embryo before the tail swelling grew out, so as to break and obliterate its connection with the former. This strand of cells, which is seen to be apparently tubular, is the anal extremity of the gut, and seems to be closed posteriorly. It is found to extend forwards, as development proceeds, as a flattened tube, lying just below the notochord or cartilaginous axis of the embryo as shown at *i*, Figs. 12 and 13. The intestine was probably continuous with the medullary canal posteriorly, from the hinder extremity of which it has possibly been invaginated from above, in which case the *gastrula* stage of development of the teleostean fish embryo would be perfectly homologous

with that of many other vertebrates. Our observations, it is admitted, do not rest upon the evidence presented by sections, but upon the appearances of the living transparent objects. The intestine is at first solid anteriorly; its lumen is a mere capillary tube on its first appearance behind. It does not appear to originate directly from longitudinal folds of the hypoblast which coalese in the middle line below, in some higher forms, but as a nearly solid band of cells just beneath the notochord.

It will be proper to discuss in this place the nature of the peculiar vesicle first described by Kupffer, and known as Kupffer's vesicle, but recently renamed the post-anal vesicle by Balfour.* It appears in all the cases which we have observed either some time before the closure of the blastoderm, or nearly at the time it closes. It is situated just beneath the tail, between the latter and the yelk. It appears in the Spanish mackerel before the blastoderm closes, and, as far as I can make out, is simply a vacuole filled with fluid, the direct connection of which with the posterior end of the rudimentary intestine, as has been held, has still to be satisfactorily demonstrated. In some forms it persists for a considerable time after the closure of the blastoderm, and is so far anterior to the point of closure that it is difficult to see how it can stand in a post-anal relation to the gut, the anal portion of which is developed almost at a point coincident with that where the closure of the blastoderm takes place, and behind the position of the vesicle. Moreover it is usually asymmetrical in position and finally disappears. Its form and position vary also in different eggs, so that I am at a loss to clearly understand its significance. That it cannot originate at the moment of the closure is proved by the fact that in some forms it is present when the blastoderm has covered but three-fourths of the yelk. I have never seen any communication between it and the medullary canal; however, its further discussion will be resumed when we come to consider forms in which it is more prominently developed. It clearly remains a fact, however, that the anal part of the gut is the first to be developed; that the œsophagus for a time appears to be a solid band of hypoblast cells below the head, while the point where the mouth will open is not indicated until twenty hours after the young fish has escaped from the egg; the vent therefore appears about thirty hours before the mouth.

The notochord *ch* appears in embryos eleven hours old as a rod of cells not different in character from those of the other portions of the blastoderm, but shortly afterwards in the region of the trunk of the embryo clearer cells make their appearance in the notochord, lenticular in form and arranged transversely to its axis. They may be seen to grow larger and larger until the primitive chorda cells form only thin transverse partitions, between which the large, clear cells are developed. Eventually the partitions entirely disappear, when the large, trans-

* Comp. Embryol., ii, p. 61.

parent cells become crowded upon each other, and now compose the entire medullary substance of the notochord, which is functionally the backbone or axis of the embryo fish. This metamorphosis of the primitive chorda cells begins about the twelfth hour in the embryo mackerel, and is completed by the time of hatching, and, like in the herring as described by Kupffer, the caudal end of the notochord is the last to undergo the change. The notochord for a considerable time after hatching does not become distinct at its caudal end from the cellular mass in which it terminates. The membranous sheath in which the notochord is inclosed seems to be differentiated when the metamorphosis of the primitive chorda cells into the clear axis rod or notochord has been completed. I have not succeeded in demonstrating from which one of the primary embryonic layers of the mackerel the primitive chorda and consequently the notochord are derived; the weight of the evidence afforded by the researches of others would appear, however, to indicate that it is split off from the lower edge of the keel or carina of the medullary canal just over the hypoblast.

The axis of the embryo is at first marked by a shallow groove which, by the time the blastoderm is closed, is completely obliterated, the last portion of it to disappear being the caudal. The blastoderm is pushed down before this groove, and when the latter closes dorsally and the medullary canal, neural canal, or neurula is formed, as it has been variously called. Certain anterior portions of it become differentiated into the various parts of the brain. Primitively the brain of the mackerel is much compressed laterally, as shown in Fig. 8. At the extreme anterior end a pair of lateral outgrowths, at first apparently solid, appear as the rudiments of the eyes, *opv*. The basal portions by which they are in communication with the fore part of the brain become partially the optic or second pair of nerves. With the more advanced development of the embryo these outgrowths become hollow and cup-like, the retina of the eye is developed on their inner surfaces, while a mesoblastic layer of pigment cells is developed on the outside to form the choroid coat. The cup has a cleft in its lower margin which closes later, and is known as the choroidal fissure. Covering the optic cups is the embryonic epithelial stratum of cells; from it an induplication is pushed into the cups, which is eventually constricted off from the parent layer, and becomes differentiated into a highly refringent spherical lens. Between the lens and the floor of the cup a space is formed very early which becomes the vitreous humor of the eye, and in front the lens is again roofed over by a very thin concavo-convex hyaline membrane, the cornea, likewise derived from the epidermis, between which and the lens the aqueous humor is confined. The iris appears to be developed from the extreme edges of the optic cup and becomes very brilliantly pigmented in a few days after the fish is hatched. The anterior part of the brain, from which the optic cups grow out, becomes the cerebrum or fore brain, in part, also, the optic chiasma. The spinal

cord or medulla is at first nearly a perfectly solid cord or strand of cells; a canal makes its appearance in its center after the muscular somites have been differentiated.

The rudiments of the ears, or auditory organs, in the embryo mackerel make their appearance soon after the optic cups, as slight elevations or welts on each side of the region of the embryonic hind brain, *au*, Fig. 8. The ridge or welt is simply the lip or prominent border of the auditory pit, which is being pushed inward from the outside in a cup-like manner from the inner sensory layer of the epiblast. It soon, however, becomes a closed sack, Fig. 10, *au*, and by the eighteenth hour two calcareous otoliths are visible in it, as shown in Fig. 12. The complications of structure which develop in the ear beyond this point relate chiefly to the formation of the semicircular canals, and these are developed some time after hatching as ridges or folds on the inner surface of the auditory sack, the walls of which grow inward from above and laterally, joining each other in such a manner that the anterior and posterior vertical and horizontal semicircular canals are limited by them; the sacculus and the otoliths lodged in it, consisting of the asterisk and sagitta, finally occupy the lower anterior part of the sack, and the auditory, or seventh nerve, enters it in their vicinity. The auditory sacks, or vesicles, are now almost, or quite, as large as the eyes, and lie on either side of the cerebellum *cer*, and medulla oblongata *mo*, as shown in Fig. 17.

The nasal pits *na*, Figs. 10 and 12, are at first simple saccular depressions differentiated from the epiblast in front of the eyes, between the latter and the anterior end of the fore brain. At the age of one week, Fig. 17, *na*, they are neat, cup-like structures, situated some distance from the edge of the upper border of the mouth just in front of the eyes. At this time it is already possible to demonstrate special sensory cells in their walls. At a still later period the nasal pits are bridged over transversely by a coalescence of a part of their opposite edges, so that an anterior and a posterior opening is formed; these communicate with each other beneath the bridge of tissue, and constitute the external nares or olfactory organ of the type characteristic of the true fishes. At what period this last type of structure is developed in the mackerel has not been learned, as it was not formed in the oldest embryos studied by the writer.

The several portions of the brain begin to be clearly marked off from each other at the eighteenth hour, when the fore-brain or cerebrum, the mid-brain between the eyes, and the medulla oblongata behind the latter may be distinguished. When the young fish is hatched, Fig. 13, all of the divisions may be distinguished, as the cerebellum is now clearly marked off from the medulla. When the medullary groove closed in the region of the brain, a laterally flattened tube was the result, and there is no such extensive anterior downward flexure of the brain on itself as is observed in higher types. As the various constric-

tions appear in the walls of the brain tube, the cavity inside becomes divided into the so-called ventricles or cavities of the primitive cerebral vesicles. As development proceeds the cerebral vesicles rapidly dilate in a lateral direction, especially the mid-brain *mb*, in which a surprisingly spacious cavity is formed in some species, which answers to the passage-way from the third to the fourth ventricles of the higher forms. Between the fore-brain and mid-brain the pineal gland *pn* is developed; while the hypophysis cerebri or pituitary body depends from the floor of the brain down between the trabeculæ cranii. The fore-brain is at first not bifid or divided into hemispheres; its division occurs comparatively late in embryonic life. The mid-brain is the most conspicuous portion of the encephalon or entire brain of the young fish, and soon after hatching its lateral free lobes grow backwards and downwards somewhat at the sides, and more or less extensively cover the cerebellum.

At fourteen hours the embryos begin to show signs of the development of pigment just below the superficial layers of the epiblast; these cells are at first scattered irregularly over the body of the embryo and gradually grow darker; as they do this they also become irregular in form and flattened, with a number of points running out from them, as shown in Fig. 12. Later they tend to aggregate on certain parts of the body, as shown in Fig. 13, where they form a band on the tail and spots on the back; as the embryo becomes still older a band of them is formed behind the ear. They are now still more irregular in form and have evidently rearranged themselves very remarkably since the fourteenth hour; the rearrangement appears to be accomplished by their migration towards definite points by means of an amœboid movement of their entire substance. When fully developed the nucleus becomes very distinct, enveloped as it is in very dark protoplasm, and the prolongations of the latter look not unlike the pseudopods of those remarkably simple animals the *Amœbæ*.

By the eighteenth hour the oil sphere found embedded in the yelk of the Spanish mackerel was observed to be enveloped in a mantle of cells apparently of hypoblastic origin, which fastens it firmly to the wall of the yelk sack below and opposite the embryo, Fig. 12. By the time the young fish is ready to hatch, the covering of the oil sphere is found to be more or less covered with pigment, which seems to have in part developed in the cellular mantle, as indicated in Fig. 13. The fixation of the bouyant oil sphere to the ventral wall of the yelk sack makes the latter bouyant, so that when the young fish escapes from the egg-membrane it is turned wrong side up, and is not until some time after hatching that it has the power to right itself and counteract the bouyancy of the globe of oil.

The heart of the young mackerel, like that of the cod, originates in a mass of mesoblast cells, which are coarser in character than those in the immediate neighborhood; they appear to be budded off from the

mesoblastic roof of the cardiac portion of the segmentation cavity lying beneath the head; at first there is no definite arrangement of the cells destined to become the heart, but they seem to be spread out in a loose mass between the hypoblast and the mesoblast at the point where the heart will appear. As soon as they have grown down and come into contact with the hypoblast a circular space or cavity is formed in their midst, which is the rudiment of the heart of the mackerel in its simplest possible form. It is now nothing more than a wide circle of coarse cells interposed between the mesoblast and hypoblast, so that one may look through the lumen or opening in the ring either from above or below. In the process of growth this ring of cells is drawn out into the primitively simple tubular heart, the hypoblastic or venous end being dragged forward while the branchial or aortic end is directed backwards. Thanks to the transparency of these embryos, every step of the process may be seen just as I have described it. By the eighteenth hour the heart *h*, Fig. 12, is fusiform and open at the venous end, and still bound to the hypoblast, and now begins to contract slowly and at long intervals, although there are still no blood corpuscles visible in the fluid held in its cavity. The next change observed is from this point onwards, when its anterior end is bent to the left and finally opens backward, and it is now clearly determined that the wide backwardly directed portion will become the venus sinus and Cuvierian ducts; the point where the bend is made will become the ventricle and the other narrow end the bulbus aortæ. At no time, nor in any form, have I seen any evidence of the origin of the cavity of the heart by the coalescence of two distinct spaces, as described in the development of other types of vertebrates.

The embryo on the eve of hatching has a relatively shorter tail than most other types of true fishes, and when just hatched measures a little more than one-eleventh of an inch in total length. It usually escapes head first from the egg, and manifests a singularly quiescent disposition, but as it grows older and begins to right itself, as its oil sphere becomes smaller, it will settle on the bottom of the vessel in which it is confined, but if disturbed it will dart off and out of the way with great quickness, and shows a disposition to avoid danger. The yelk has diminished in bulk before the egg-membrane is ruptured, because the embryo fish has grown at its expense, and a considerable quantity of protoplasmic matter has doubtless been budding off from it in consequence of the formation of free nuclei, which are found, in other species at least, in the superficial layers of the yelk just below the embryo. The diminution of the bulk of the yelk is not due to the development of the blood, which is not yet discoverable, nor will it appear until some time after the young fish has left the egg.

The rudiments of the breast fins appear just before hatching as a pair of delicate rounded folds, which, have a horizontal direction at the base, and which grow out on each side of the body in the vertical from the oil sphere. They may be regarded, therefore, as having very little

genetic affinity to the gill arches, from which they are separated by an amazingly wide interval, as shown in Fig. 13, in which their position is indicated at *ff*.

STRUCTURES DEVELOPED IN THE YOUNG SPANISH MACKEREL AFTER HATCHING.

Twelve hours after the young fish has left the egg-membrane it has the appearance represented in Fig. 14; the yelk has diminished very perceptibly in size, while the anterior end of the head is considerably prolonged forwards as compared with its condition in the recently-hatched embryo shown in Fig. 13. The yelk in collapsing also leaves the hind portion of the intestine in an apparently more posterior position, while behind the latter the rudimentary urinary bladder *al* is very distinctly shown as a vesicle from which the simple tubular prolongation of the Wolffian duct *wd* passes up behind and above the intestine. The Wolffian duct appears to develop comparatively late in the mackerel, as it is difficult to make out anything corresponding to it before the young fish leaves the egg. It would appear to originate from the peritoneal (splanchnopleural) wall of the abdominal cavity, and to be continued on either side into the urinary vesicle or bladder *al*, which opens outward immediately behind the vent. During the latter stages of development, or from the fourth to the seventh day, the hind portion of the Wolffian duct acquires a decided flexure just before it enters the bladder, as indicated in Figs. 16 and 17. This hinder portion may be considered to probably represent the rudiments of the urinary ducts or ureters of still more advanced stages of development.

"The excretory system commences [in true fishes] with the formation of a [longitudinally disposed, paired] segmental duct, formed by a constriction of the parietal wall of the peritoneal cavity. The anterior end remains open to the body cavity, and forms a pronephros (head kidney). On the inner side of, and opposite this opening a glomerulus is developed, and the part of the body cavity containing both the glomerulus and the opening of the pronephros becomes shut off from the remainder of the body cavity, and forms a completely closed Malpighian capsule. The mesonephros (Wolffian body) is late in developing."*

I believe it possible, however, from my own studies on some forms, to show that a system of segmental tubes joins the segmental ducts at a late stage of development, which pass into glomeruli which lie for the most part along the middle line of the dorsal wall of the abdominal cavity, close to the median dorsal aortic vessel.

Upon the origin of the generative structures of the young mackerel I have made no observations, but their position in the adult would show that, as in other fish-like types, they must originate as specializations of tissue tracts on either side of the mesenteric suspensor of the intestine.

* Comp. Embryol. Balfour, ii, p. 63.

In Fig. 14 a large sinus, *ss*, is shown just over the brain, which is roofed over by the dermal and deeper layers of the epiblast; the cavity so formed is filled with fluid and persists for at least a week, as shown in Fig. 17. Below the hinder part of the head and at its sides, in Fig. 14, the branchial furrows *br* are visible; as these become deeper they are finally broken through into the wide branchial chamber of the fore-gut, as the gill-clefts. This takes place about twenty-four hours after hatching, and is on the eve of accomplishment in Fig. 15, in which the point where the mouth will appear is indicated at *m* on the lower side of the head; just behind the point where the mouth will soon break through, the rudiment of the lower jaw has made its appearance as Meckel's cartilage, *mk*. Above and behind it the cartilaginous rudiments of the branchial skeleton or framework of the gills have been in part developed. It will also be noticed that the head is higher and that the brain is bent downwards more than in Fig. 14, in consequence of the decrease in size of the yelk sack. The mandibular arch, the forepart of which is indicated at *mk*, does not yet reach forwards on a line with the end of the snout. While the hyoid arch, or that immediately following the mandibular, is still more or less obscured by the latter, and covered up by it externally, behind which the branchial arches or rudimentary gills are more crowded together from before backwards than in the stage shown in Fig. 14. The trabeculæ cranii have, however, been developed, but are still rudimentary, being present only as a pair of symmetrically disposed longitudinal rods beneath the brain. The eye, which was not heretofore completely pigmented, is now quite black and opaque, the choroid layer being developed. The ear and nasal pits have undergone farther development; the latter are present as distinct cups in front of the eyes. The heart has undergone considerable advance, in that its posterior end is now directed upwards, while the ventricle and bulbus aortæ are more fully developed and actively pulsating, although the blood system is still imperfect, no true aortic or venous channel having as yet been developed; however, there is already a partial branchial and cephalic circulation, but the blood channels are not yet supplied with a sufficient number of blood corpuscles to mark their courses distinctly by the color. The cavity in which the heart now lies is bounded in front by the branchial structures, below by what was formerly the anterior portion of the epiblastic sack covering the yelk, behind by the hypoblastic walls of the yelk sack, above by the intestine and body walls. In this and earlier stages of development I believe that I have seen blood corpuscles swimming freely in the cavity surrounding the heart, which would indicate that they had been derived by budding directly from the hypoblast, which is beyond the shadow of a doubt the way in which they are developed in the embryo silver-gar, or bill-fish (*Belone*). The yelk sack is shown much reduced and more strongly pigmented in Fig. 15, while the oil sphere has undergone considerable reduction in size. The widest portion of the young mack

cord is now from side to side, through the eyes, the body seeming to be concentrated towards the head. The breast fin *bf*, Fig. 14, is still a semi-circular lobe, with its base nearly horizontal, but it has been advanced forwards somewhat twelve hours after hatching. It is merely a flattened epiblastic pouch into which has grown a tract of mesoblastic tissue. Twenty-one hours after hatching the breast fin has acquired a vertical position, as shown in Fig. 15, while the coraco-scapular cartilage *csc* is in its incipient stages of development in its base. Up to this time the intestine has maintained its primitive character as a horizontally flattened tube, which it will not begin to lose for twenty-four hours more, but below the breast fin a swelling has appeared in its lower wall, *lv*, which is the rudiment of the liver.

Embryos on the fourth day after development have the appearance shown in Fig. 16. The most marked advance which has made over the stage, shown in Fig. 15, is that the intestine has acquired a cylindrical form, and is hollow or tubular, while it also has been bent upon itself in its middle region. The liver is now a very prominent ventral sack-like outgrowth from the lower side of the intestine at *lv*, just in front of the bend in the alimentary canal. Its structure already shows a lobular character, its walls being subdivided into the rudiments of hepatic follicles. The epithelium over the rest of the inner surface of the intestine becomes differentiated into follicles at a very early period, which would indicate that the mucous membrane of the intestine had a specific, probably digestive function, as soon as the follicular structures were developed, which is accomplished about the time the young fish commences to feed. Outside of the epithelial layer the annular and longitudinal muscular layer of the intestine appears about the same time, and peristaltic movements of the intestinal walls begin to be manifested almost as soon as the intestine becomes tubular. Above the liver, and a little way behind it, a diverticulum appears on the fourth day, usually more or less obscured by pigment cells, which I regard as the rudiment of the air-bladder; by the seventh day it is much more plainly developed, as shown in Fig. 17, *ab*. On the fourth day the young fishes will begin to feed, as represented in Fig. 16, where the black mass *f* represents the remains of food in the hind gut which the animal had swallowed. From an examination of several specimens I am not able, however, to state what this food was, as it was in a much too disorganized condition to tell of what it originally consisted. The oil sphere *os* is now nearly absorbed as well as the yelk, which is entirely gone. A portion of the anterior wall of the yelk sack, however, has remained as a septum, partially shutting off the pericardiac cavity from the body cavity, in which the viscera are contained; it stretches across between the lower ends of the coraco-scapular cartilages *csc*. The circulation is now fully established, there being an aorta and cardinal veins, *cv*, which return below it to carry the blood back to the heart, a portion, however, first passing through a vascular network over the viscera and represent-

ing essentially a portal system of vessels. The blood is forced through the branchial arches, and passes from them into the carotid arteries and aorta, to return to the heart again by way of the jugular and cardinal veins and visceral network. The venous or dorsal end of the heart is divided by the intestine, the Cuvierian ducts opening on either side of it upwards and backwards.

It will be worth while to here notice the fact that in the mackerel there is nothing which is comparable with a system of vitelline vessels, such as is found in the young salmon, stickleback and silver gar, but that the venous end of the heart is throughout the whole of embryonic life closely applied to the surface of the yelk sack (see Figs. 14, 15, 16, and 17), so that it appears at times almost like a parasite sucking at the vitellus. Stray colorless blood corpuscles may sometimes be seen in the pericardiac cavity, say about a day after hatching, which would indicate that the genesis of the blood from the vitellus was essentially the same as that in the silver gar, where the fluid surrounding the heart contains multitudes of colored blood disks, and where one can observe them in every stage of metamorphosis from the substance of the vitellus, at the point where the long tubular venous sinus of these embryos joins the hypoblast of the yelk. At the end of the fourth day the mouth of the young mackerel is wide open and the lower jaw, in consequence of the greater length of Meckel's cartilage, reaches nearly as far forward as the upper jaw or snout. The mouth is also frequently opened and closed at this time by the mandibular and hyoid muscles. The chondrocranium has also advanced in development in all of its parts, since the auditory capsule is now clearly inclosed in an investment of cartilage cells, which are joined to the notochord anteriorly by the development of the so-called parachordal cartilages. Under the brain, the primitive cartilaginous bars, the trabeculæ cranii, are developed, and an oval space exists between them, into which the hypophysis cerebri or pituitary body dips downwards. On either side, and below the hinder half of the eyes, the pterygoid cartilages have been developed at the same time hyoid, quadrate, hyomandibular, ceratohyal, branchial, and coraco-scapular elements have advanced in development.

The method which I have found the best to demonstrate the cartilages of the head in fishes as small as the mackerel, which measures only a little over one-seventh of an inch at this stage, is the following: crush a recently killed specimen under a Fol's compressor so as to flatten it sufficiently to let the light through it, then use a one per cent. solution of acetic acid so as to bring out the contours of the cartilages with their cells and nuclei. If this is carefully done there will not be sufficient displacement or disarrangement of the parts of the skull to render their identification at all difficult.

Figure 17 represents the head of a young mackerel nearly a week old dissected so as to show the structure of the skull as nearly as such a difficult subject admits of representation. The parts of the chondo

cranium are lettered so that their names may easily be made out from the list of reference letters. I have attempted to show the arrangement of the pavement of choroid cells, *cc*, in the eye as may be shown in preparations mounted in balsam. I would also direct especial attention to the conical teeth represented on the epithelium of the lower jaw. These seem to be developed in epithelial pits and are not in direct connection with the skeleton of the jaw, which is, moreover, not yet bony. They surmount little epithelial papillæ and grow by the addition of material from below: their composition does not appear to be calcareous, but corneous, since I find them to resist the action of acids. Rathke has described teeth of a somewhat similar character in the embryos of the viviparous blenny (*Zoarces*).

In embryos of this age the branchial leaflets are also developed. They at first appear on the posterior border of the gill arches as small papillæ, which, as they elongate, throw out processes from their edges, so that they eventually acquire a bipinnate structure. In these bipinnate fleshy processes capillary loops are formed, which communicate between the branchial arteries and veins. The leaflets with their capillaries are the agents directly concerned in the aeration of the blood of the young fish.

The coraco-scapular rods *csc*, although apparently cartilaginous, have an histological composition different from the cartilages of the head, being much more hyaline. It is also embedded in a vertical fold which extends some way beyond the upper and lower borders of the breast fin. This may be called the pectoral fold. It is not at all improbable that we will yet find embryo Teleosts in which there are continuous lateral folds, for we already know species in which the primitive natatory fold is discontinuous at a very early age. Such is the case with *Hippocampus* and *Syngnathus*, according to my own observations this season. *Hippocampus* never develops a caudal fin, so that we would naturally not expect to find the natatory fold prolonged over the end of the tail; but the posterior position of the early rudiments of the pectorals in *Cybium* and *Parephippus*, it appears to me, is a very strong argument against their origin from a posterior branchial arch; indeed, it is the strongest yet offered against that doctrine by any data derived from a study of the development of the paired fins of Teleosts. In other words, since we now know that the natatory fold, from which the unpaired median fins are developed, is sometimes discontinuous, I see no reason why we should not expect to find the lateral fin-folds discontinuous, as there are more reasons why they should be so in the Teleost than in the Elasmobranch embryo. In fact, it would appear that the greater the longitudinal extent of the unpaired fins in proportion to the length of the body of the adult the more likelihood there is of finding a continuous dorsal and ventral natatory fold developed in the larva, and *vice versa*. The longitudinal extent of the paired fins of Teleost fishes is less, vastly less, in respect to the number of rays, than those of the Elasmobranchs,

and in consequence of this difference alone we should not be surprised to find lateral fin-folds of considerable extent in the embryo of the latter and of limited extent in the former. Viewed in this way, we may prove too much for the doctrine of the origin of the paired fins from lateral folds. The truth of the matter appears to be that we ought to quietly wait for more facts before generalizing with the data obtained from only one group.

SUMMARY OF ANATOMICAL RESULTS, BASED ON ALL OF THE SPECIES STUDIED BY THE AUTHOR.

The following are the more important anatomical and embryological facts which have been ascertained; only such as are essentially new to science or which receive new or fuller interpretations are noticed:

1. The segmentation cavity or blastocœl is developed with the growth of the blastoderm so as to almost entirely surround and include the yelk, and persists until late in embryonic life.

2. The somatopleure (muscular layer) and splanchnopleure (peritoneal layer) grow down into the segmentation cavity on either side between the epiblast and hypoblast (*Oncorhynchus*).

3. The heart develops in an extension of the segmentation cavity beneath the head.

4. The blood is of hypoblastic origin.

5. The germinal disk is formed by the aggregation at one pole of the germinal matter covering the vitellus (*Cybium*), or scattered through it as a meshwork joined to the peripheral layer (*Alosa*).

6. Segmentation in the early stages is more or less decidedly rhythmical, with alternating periods of activity and longer periods of rest.

7. The egg-membrane is not always a *zona radiata*, sometimes having no pore canals; a micropyle is always present.

8. The egg-membranes of the ova of certain genera (*Chirostoma*, *Belone*, *Scomberesox*, *Hemirhamphus*) are provided with filaments or thread-like appendages externally, by which they become attached to fixed objects in the water while hatching.

9. The egg-membrane may be absent, and replaced by a highly vascular ovarian follicle, perforated by a follicular foramen in some viviparous forms (*Zygonectes*).

10. The median unpaired fins originate from a dorsal and ventral natatory fold, which may be continuous (*Cybium*, *Gadus*), or be discontinuous at the very first (*Syngnathus*, *Hippocampus*), or be discontinuous very early (*Zygonectes*).

11. The pectoral is the first of the paired fins to be developed from a short lateral horizontal fold, the position of which varies in different genera, appearing very far back at first in some, farther forward and nearer the branchial arches in others.

12. The primitive cartilaginous coraco-scapular arch or shoulder-

girdle is of mesoblastic origin, and appears just beneath what may be called the pectoral fold at the base of the breast fin. Its form and position varies in different genera.

13. The proctodeum or vent of the young fish appears long before the stomodeum or mouth; the intestine develops from behind forward, and it is probable that the intestine and medullary canal are primitively continuous through the intermediation of a neurenteric canal.

14. The number of somites or muscular segments varies in different species at the time the tail is about to be formed, and is greatest in species in which a great number of myocommata are developed in the adult, least in those in which the adult has fewer pairs of myocommata.

PRACTICAL CONCLUSIONS.

In the preceding account of the development of the Spanish mackerel, it has been incidentally mentioned that the eggs of this fish are buoyant, apparently from the presence of a large oil sphere in the vitellus, and not because of the diminished specific gravity of the whole ovum, as appears to be the case with the cod egg. We would now insist upon this character as being of such great physiological import that we cannot afford to ignore it or to conduct our hatching work without taking cognizance of it in the construction of apparatus. The perfectly regular development of the ova was found to take place practically at the surface of the water, while those which sank to the bottom were considered, in the light of experience, as not liable to develop at all. Where the eggs were kept for the whole period of incubation in still water in a marbleized pan, all that sank could be regarded as irrecoverably lost, while those which remained floating at the surface as uniformly hatched out. Changing the water on a lot of ova three or four times in twenty-four hours in a pan gave almost as good results as any other method employed. The active movement of the ova in apparatus devised to hatch other species with heavy ova was amongst the least successful modes, and especially where metals, such as copper, brass, tin, or nickle, were used in the construction of the hatching vessels or screens. Inasmuch as the protoplasm of the living egg is extraordinarily sensitive to the poisonous effects of all metallic salts, such a result is no more than might have been expected. We have therefore been constrained to suggest the use of apparatus which, as far as practicable, was constructed of wood, glass, or of some material indifferent to the action of sea-water. Experiments made, at the suggestion of Professor Baird, with asphalt varnish and rubber paint at Cherrystone taught us that it was possible to coat metallic surfaces with an inert substance which would prevent the corrosion of the metallic vessels used in hatching, and hitherto found to be so fatally injurious to developing fish ova of every kind.

The percentage of losses in every case was large, and I doubt if 25

per cent. of the whole number of eggs was ever hatched out even under the most favorable conditions. The utility of some cheap and effective glass apparatus is very apparent from experiments made by Colonel McDonald, as his system admits of a wide range of application. Other methods, especially those in which the intermittently active siphon principle was applied, seem to afford some promise that a successful apparatus may yet be devised to work on that plan. Some trials of such apparatus made by Colonel McDonald were promising, but I leave the results attained for him to report upon. An equally simple hatching box was extemporized by Mr. Sauerhoff with a Ferguson cylinder set into a tub, the eggs being placed in the cylinder and the constant water supply allowed to escape through its sides and bottom into the tub outside and run off by a proper outlet. With this apparatus a fair degree of success was obtained.

It may be stated as a general principle that buoyant ova must have gentle treatment. That if they are much agitated in the water they tend to be injured and are carried to the bottom, where they die. It appeared that when the normal buoyant tendencies of the ova were interfered with by any of our methods large losses were the result, and that the nearer our methods approached the natural environment of naturally spawned ova in the open sea the more successful we were. To forcibly immerse the egg of the mackerel, and keep it immersed, would simply be to thwart what is most palpably a normal condition of its life at the surface of the water.

The fertility of the mackerel, like that of most fishes with floating ova, is very great, and it is to be expected that the mortality of the ova will be in proportion to the fertility of the species. This seems to be borne out by the converse state of affairs in the stickleback and top-minnow, where a small number of embryos are matured, but are developed, with little or no losses, in a nest, and are nursed by the male or viviparously in the body of the female. Viewed in this light, we should expect large losses in hatching the cod, Spanish mackerel, moonfish, and bonito or crab-eater.

The young fish began to feed on the fourth day after development had begun, and on the third day after hatching. The true nature of the food was not determined, as it was seen in the intestines of only a few specimens. Inasmuch as the young fish by the end of the first week of their life already have teeth, it is easy to believe that their food consists almost entirely of small articulate animals, which, with their quick darting movements, they might readily single out and capture while swimming about in water in which such prey abounded.

EXPLANATION OF THE LETTERS OF REFERENCE USED IN PLATES I–IV.

ab. Air-bladder.
al. Urinary bladder.
at. Atrium or venous sinus.
au. Auditory vesicle or internal ear.
ba. Bulbus aortæ.
bf. Breast or pectoral fin.
br. Branchiæ or branchial arches.
cc. Choroid layer of cells; lamina fusca.
ce. Cerebrum.
cer. Cerebellum.
ch. Chorda dorsalis or notochord.
chy. Ceratohyal cartilage.
cr. Carina.
crs. Cardiac sinus; rudiment of pericardiac space.
csc. Caraco-scapular cartilage or rod.
cv. Caudal vein.
ep. Epiblast or sensory skin layer.
f. Remains of food in intestine.
ff. Fin-fold; rudiment of breast fin
gd. Germinal disk.
gp. Germinal layer or pellicle.
h. Heart.
hy. Hypoblast or inner mucous layer.
hy′. Hyoid cartilage.
i, i′. Intestine.
lv. Liver.
m. Medulla spinalis or spinal cord.
mb. Midbrain or optic lobes.
mc. Medullary canal.
mk. Meckel's cartilage.
mo. Medulla oblongata.
na. Nasal pit.
nf. Dorsal and ventral natatory fold or fin.
op. Operculum.
opv. Optic vesicle.
os. Oil sphere.
pc. Pigment cells.
pn. Pineal gland.
pp. Papular prominences.
q. Quadrate.
r. Rim of blastoderm.

sg. Segmentation cavity.
so. Somites or segments of the muscle plates.
ss. Supracephalic sinus.
tr. Trabeculæ cranii.
v. Vent.
ve. Ventricle.
wd. Wolffian duct.
zr. Egg-membrane.
y. Yelk.

EXPLANATION OF PLATE I.

FIG. 1.—Micropyle and micropylar area, in two positions, of an unimpregnated egg of the Spanish mackerel. × 64.*

FIG. 2.—Unimpregnated egg of the Spanish mackerel, showing the germinal layer or pellicle *gp* which envelopes the yelk or vitellus. × 24.

FIG. 3.—Morula stage of cleavage of the germinal disk of the egg of the Spanish mackerel one hour and forty minutes after impregnation. × 25.

FIG. 4.—Germinal disk of a Spanish mackerel egg shown with its germinal pole slightly inclined towards the observer. The disk *gd* is elevated and biscuit-shaped, and is surrounded at its base by a circle of two rows of flattened cells lying immediately upon the yelk. The cells in the disk are four or more deep at this stage, three hours after impregnation. × 70.

FIG. 5.—Incipient blastoderm of the egg of the Spanish mackerel, viewed from the side somewhat obliquely. The segmentation of the marginal cells has advanced somewhat as compared with Fig. 4, and it is clear that they will become a part of the rim of the blastoderm. × 25.

FIG. 6.—Developing blastoderm of an egg three hours and thirty minutes after impregnation, viewed from above, showing the blastodermic rim *r* in its incipiency, while the darker space bounded by it corresponds with the area beneath the blastoderm shortly to become the segmentation cavity. × 25.

FIG. 7.—Blastoderm of the Spanish mackerel egg seven hours after impregnation, inclosing nearly half of the yelk, and showing the lumen of the segmentation cavity on one side at *sg*, which extends beneath the fore part of the head at *crs* to form the rudiment of the cardiac sinus just in front of the carina *cr*. × 48.

FIG. 8.—Embryo of the Spanish mackerel eleven hours after impregnation, showing the rudiments of the optic vesicles *opv*, the chorda *ch*, and the cardiac sinus *crs*. The segmentation cavity *sg* is shown between the epiblast and hypoblast extending nearly all round the yelk. The blastoderm has not yet closed behind the tail. × 50.

*In every case the number of diameters to which the figure is enlarged is indicated in Arabic numerals preceded by the sign ×.

SPANISH MACKEREL (*Cybium maculatum*).

EXPLANATION OF PLATE II.

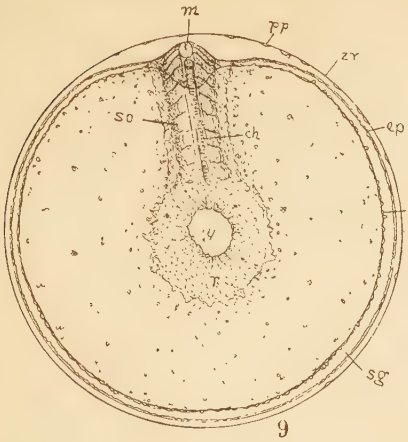
FIG. 9.—Spanish mackerel egg viewed so as to show only the caudal end of the embryo twelve hours after impregnation, showing the lumen of the segmentation cavity *sg*, the rudimentary chorda, and the somites or muscle plates, while the blastoderm has not yet quite closed over the yelk at *y*. The oil sphere is not represented. × 50.

FIG. 10.—Embryo Spanish mackerel fourteen hours after impregnation. × 50.

FIG. 11.—Transverse section through the opening *y* of the embryo represented in Fig. 9.

FIG. 12.—Spanish mackerel embryo eighteen hours after impregnation. The rudimentary heart *h* occupies an asymmetrical position in its sinus beneath the head and is a fusiform tubular organ open at the anterior venous end. The oil sphere is attached to the ventral wall of the yelk sack or hypoblast and is partly covered by flattened cells which have budded from it. × 50.

FIG. 13.—Young Spanish mackerel just hatched twenty-four hours after impregnation. The rudiments of the breast fins have made their appearance on each side of the body at *ff*, and the oil sphere is having pigment cells developed on its surface, while those of the body are already aggregated in patches on the tail. × 25.



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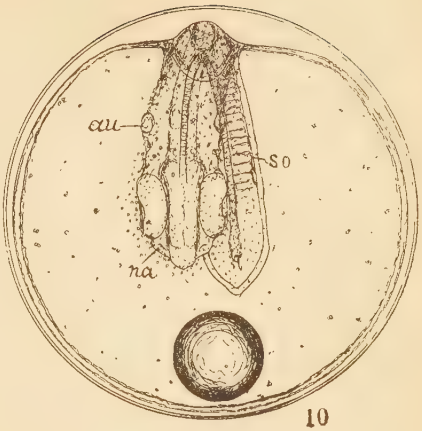

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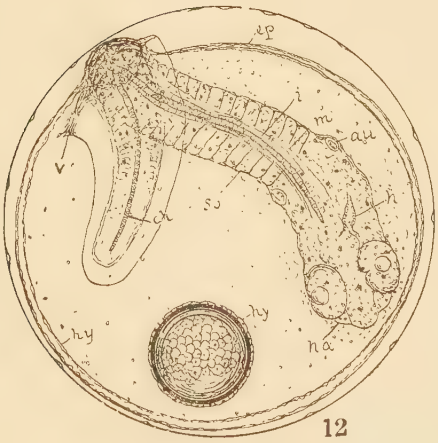

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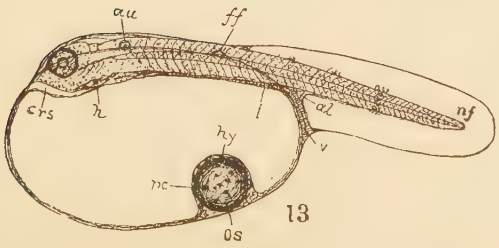

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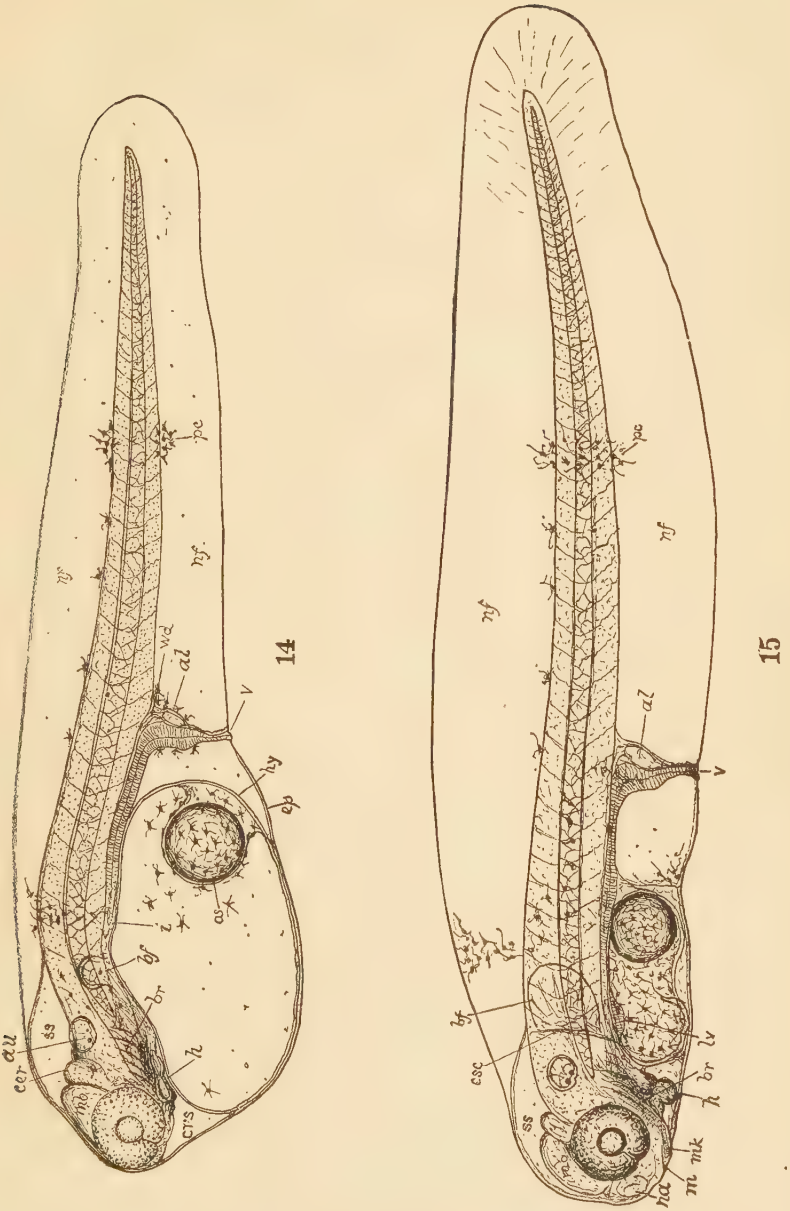
SPANISH MACKEREL (*Cybium maculatum*).

EXPLANATION OF PLATE III.

FIG. 14.—Young Spanish mackerel thirty-six hours after development began, and twelve hours after it had left the egg. The yelk sack has begun to be absorbed somewhat, and in consequence of its gradual collapse its wall is retreating from the outer or epiblast laver so as to leave a larger cardiac space in front and a similar space behind between the sack and the intestine. The latter still retains the form of a much-flattened canal, which is still occluded in the œsophageal and oral regions, where it is not yet broken through as a mouth, though the branchial furrows have made their appearance. The breast fin *bf* now occupies a more anterior position as a vertical semicircular fold a little way behind the ear. The superficial epiblast has been elevated from the brain so as to form a space above the latter, developing the supracephalic sinus *ss*. × 50.

FIG. 15.—Young Spanish mackerel forty-five hours from the beginning of development and twenty-one hours after it has left the egg. The contents of the yelk-sack have been mostly absorbed. The point where the mouth will appear is indicated at *m*, behind which the Meckelian and branchial cartilages are appearing. The heart is more developed, and exhibits an atrium, a ventricle, and a bulbus arteriosus. The liver is appearing as a thickening on the lower side of the fore-gut at *lv*, while the hinder extremity of the Wolffian duct is now plainly visible as a simple canal above the intestine, but is widened behind the vertical portion of the hind gut into a urinary bladder, *al*. The breast fin now occupies a vertical position and the rudiment of the coraco-scapular arch or shoulder girdle has appeared in the pectoral fold at its base. A few colorless blood corpuscles have appeared in the heart, but there is still no systemic circulation. × 50.

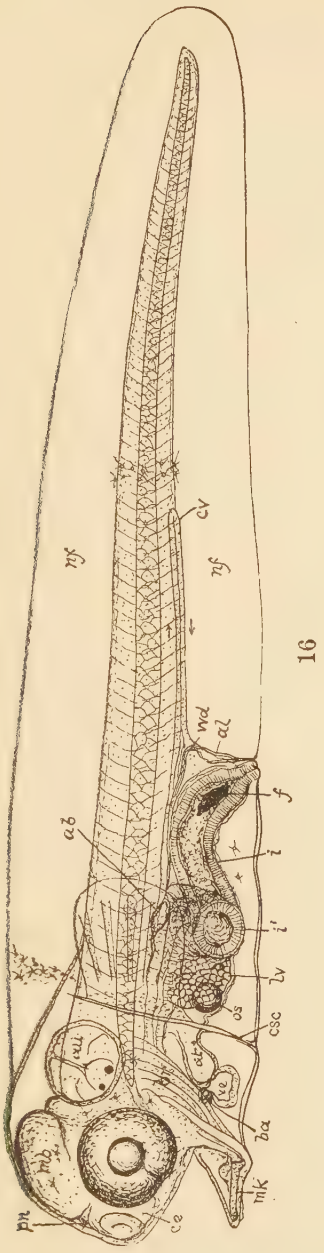


SPANISH MACKEREL (*Cybium maculatum*).

EXPLANATION OF PLATE IV.

FIG. 16.—Spanish mackerel four days after development began and three days after it had left the egg. The chondrocranium is much more developed than in Fig. 15, as is apparent from the development of the mandibular, hyoid, and branchial arches, as well as the trabeculæ cranii, parachordals, and the investment of incipient cartilage covering the ear capsules. In consequence of the advanced development of the mandibular and hyoid arches the mouth is now wide open. The caraco-scapular element *csc* at the base of the breast fin is a slender hyaline rod, different in its histological structure from that of the cartilage of the head bones, and marks the point where a transverse fold of the hypoblast partially closes off the pericardiac cavity from that of the abdomen. The liver *lv* is now more fully developed and is already divided into follicles. There is one turn of the intestine upon itself, which in this instance contains the remains of food at its hinder extremity. The circulation is now fully established, the dorsal aorta extending back for about half the length of the animal; at its posterior extremity, *cv*, it becomes the caudal vein which carries the blood forward to the heart, but not until a considerable part of it passes through a system of vessels which traverse the viscera externally, when it is poured directly into the venous sinus *at*, and so into the general circulation through the heart and gills. × 50.

FIG. 19.—Head of young Spanish mackerel on the sixth day after hatching, partly diagrammatic, showing the air-bladder *ab*, the urinary bladder *al*, the liver *lv*, more developed than in Fig. 16. The oil sphere *os* has been nearly absorbed. The chondrocranium is very much more fully developed, while well defined conical teeth have made their appearance on the papillæ of the dermal epithelium of the lower jaw, which is now longer than the upper. The opercular fold is also more prominent. × 40.



SPANISH MACKEREL (*Cybium maculatum*).

THE ARTIFICIAL PROPAGATION OF THE STRIPED BASS (ROCCUS LINEATUS) ON ALBEMARLE SOUND.

By S. G. WORTH.

OFFICE SUPERINTENDENT FISH AND FISHERIES,
Morganton, N. C., September 22, 1881.

Hon. S. F. BAIRD,
U. S. Commissioner of Fisheries, Washington, D. C.:

DEAR SIR: Some months ago I promised to write you fully upon the subject of the fertilization and hatching of rock-fish or striped bass eggs taken by me on the Albemarle Sound in the spring of 1880. Circumstances have in different ways prevented my doing so at an earlier date, but I finally undertake the task, which is one of pleasure. I shall feel more than repaid if my observations shall tend in the least to further inquiry in the same direction.

The rock fish or striped bass (*Roccus lineatus*) is found in considerable abundance in the Albemarle Sound, but it has not so frequently occurred there in the spawning state, owing perhaps to the suspension of operations at the large fisheries about or before the time the eggs ripen.

I was superintending a shad-hatching force at Avoca, and having at that time but few men who could strip shad well, had attended the seine hauls at Sutton fishery, where I took the most of the eggs myself. At eleven o'clock on the night of April 28, among a scant haul of shad and herring I found a large spawning rock-fish. I had a large number of impregnating pans ready to receive eggs, and after I had taken eggs in seven of them, commenced to apply the milt. There were only five or six males and but a portion of them ripe, and I exhausted the milt in the sixth pan. None of the males were more than 16 inches in length, and the milt was very scarce. I did not apply more than one-fourth as much as is usually applied to shad eggs. By accident, the tin dippers had been left at the hatchery, and when I discovered this I was afraid that the milt would stand too long, and I put water to the eggs by dipping each pan into the open water of the sound. An easterly storm brought heavy waves on the beach which were full of sand, small bits of wood, and other injurious substances in the form of fish scales and offal washed upon the beach where herring were cut. In the act of immersing the pans into the waves violent motion was given them in the riding and jumping sustained, and after a survey of their unfavorable handling and a comparison with the handling carefully guarded in impregnating shad eggs, I despaired of success. Finding that it was not possible to get further rock milt for the seventh pan, I took a male shad and applied to the eggs in it. All of the eggs were watered and washed, a tin pan being used as a dipper, in the same general manner adopted

with shad ova, and in an hour's time were placed into buckets and carried to a small boat. They underwent a journey of two miles, one-half of which was in the open sound, the boat's course being in the troughs of the waves. This seemed but another means of destruction that awaited them, but they were unaffected throughout. The parent fish weighed 57 pounds, and I pressed the eggs out as she lay upon the beach. In this position considerable pressure was required. The eggs were quite small, smaller than those of shad, and they possessed a decided green color. When fertilized they became transparent, and in the water could be seen only as small oily globules, which glistened brightly both in solar and lamp light. I measured the diameter of those impregnated, somewhat rudely. I found them seven and a half diameters to the inch. Finding the difference in the size of these and shad eggs (which are eight diameters), I made an estimate of the number taken. In a dipper which had been found to contain 40,000 of the latter I measured the rock-fish eggs, estimating them at 30,000 to each dipper. The contents of the seven pans, or in other words the eggs taken, amounted to 700,000. They were placed into six shad cones, a smaller number being placed in a floating box in the creek.

I bought the mature fish, and on the morning of the 29th cut her open and removed her ovaries. I removed with slight pressure an additional quantity of more than a quart of eggs. To determine the comparative bulk removed on the night preceding, I filled them at the natural openings with water. I found that the difference between the last bulk of eggs, just removed, and a bulk of water sufficient to fill the ovaries was about as four to five, or, in other words, the eggs removed for impregnation were to the eggs unused as one to four, and thereupon I based the total contents at 3,000,000.

It was not until the evening of the 29th that I believed the eggs taken to be fertilized. Then I found that fully 90 per cent. were good, the cone containing those impregnated with shad milt, however, being very low in impregnation, perhaps as many as 5 to 6 per cent. being good. At this stage they showed a less specific gravity than shad eggs, rising to the surface with but a small current from below. Great difficulty arose in the development of this new feature, as the eggs crowded the screens above on all their surface. On the night of the 30th they commenced hatching. The fry immediately began to escape through the perforated screens, and pieces of cloth were bound over the screens to arrest them. They soon clogged, and the water supply had to be reduced proportionately to prevent the cones from overflowing. Within forty-two hours all the eggs were hatched, the fish being mostly dead, owing to the reduction in volume of water. They were perfect fish, clearly out of the eggs, and many quarts in bulk. Their bodies were very small and the sack large proportionately. I removed about 40,000 alive and placed them into the floating box, where about 10,000 additional ones had hatched. I kept them two days, but there was no

current in the creek and the sun beamed down on them, destroying some, and the others followed presumably from the putrid water. There were 4,000,000 shad eggs and fish in the hatchery at the time, and the rock fry died from neglect. Two thousand hybrids were removed and kept in a shipping can for twelve days. They were watered ever two to four hours, but survived under conditions that shad fry could not have done, being near the boiler and machinery, in a high temperature all the while. They were carried to Raleigh, where it was designed to put them into a fresh-water pond, but they died at the depot on the twelfth night after they were hatched. They had sacks of good size still remaining upon them. The temperature of the water during hatching was 66° to 67° Fahrenheit.

From the recital above it may be inferred that rock-fish eggs are as easily fertilized as those of shad, and it would in addition appear that a less amount of milt is necessary. It would further appear that they are more hardy, even admitting large amounts of sand and other mechanical substances into the water while undergoing impregnation.

These points being as well determined as the limited experiments with a single lot of eggs would admit, it occurs that it only remains to ascertain the spawning localities of the parent fish when their propagation will follow. As an aid to discovering these localities it may be well to mention the capture of three spawning fish at Scotch Hall fishery in 1879. This fishery is only two miles from Avoca. In 1880 five were captured within four miles, and in 1881 three were captured at Cason and Wood's fishery, six miles from Avoca, and near the town of Edenton. All of these were of large size, probably averaging 55 pounds.

No specific mode is adopted for the capture of rock fish in these waters. Twelve of the large seines, of one and a quarter to one and a half miles in length, aggregate about 150,000 pounds per year. A great number ascend the Roanoke, the main tributary of the sound, which stream is preferred by them in their ascent. More than a hundred fishermen are engaged at intervals in the spring, fishing for them with dip-nets from dug-out boats below the falls at Weldon. They consume or sell the catch at home, but a small number being shipped away.

Dr. W. R. Capehart, the proprietor of the Avoca fisheries, made an experimental haul on May 6, 1876, which was called to notice by the late Mr. James W. Milner. His fishing operations had closed, but being induced for some cause to make the haul, he cast one of his large seines. Eight hundred and forty rock were captured, which weighed 35,000 pounds. Three hundred and fifty averaged 65 pounds, and many of these ran to 80 and 90 pounds. The roe from one female weighed 24 pounds, which must have contained, on comparative estimate, six to eight million eggs. Dr. C. had not given any attention to artificial propagation at that time, and does not know if any were ripe. In this connection it may not be inappropriate to mention that rock-fish eggs were taken at Scotch Hall fishery in 1879. Dr. Capehart, assisted by

Mr. E. H. Walke, took a large number of eggs and applied the milt. Their attention being drawn to the fishery, however, the eggs were left two or more hours in the water unchanged. They were so much crowded together, and so long unattended, that the impregnation was not very good. They were placed into the cones of the United States steamer Lookout, and were only discarded when a more perfect impregnation was attained by Mr. William Hamlin in a separate and perhaps more recent lot of eggs. Mr. Hamlin belonged to the corps of Hon. T. B. Ferguson.

Some preliminary arrangements will be made next spring toward the propagation of this fine fish, by the sub-department of fish and fisheries of North Carolina, which I have the honor to represent.

I am, yours, very respectfully,

S. G. WORTH.

ON THE RETARDATION OF THE DEVELOPMENT OF THE OVA OF THE SHAD (ALOSA SAPIDISSIMA), WITH OBSERVATIONS ON THE EGG-FUNGUS AND BACTERIA.

By JOHN A. RYDER.

Several series of experiments at different times were undertaken by persons connected with the United States Fish Commission, having for their object the solution of the following problems: "Is it possible to lower the temperature of the water in which shad eggs are incubated so as to greatly retard and prolong the process?" "Is it possible to prolong the period of incubation so that large quantities of embryonized ova may be carried for long distances by land or water so as to effectively stock distant or foreign waters?" These two queries, I think, clearly state the objects of the experiments, and also tacitly indicate the important results which would follow in case practical results should be attained.

That a decrease in temperature would impede or retard the development of ova has been known for a long time, and, without encumbering this essay with references, it may be asserted as a truth based on physical reasons and facts. Physiologists and biological philosophers, such as H. Milne-Edwards and Herbert Spencer, have recognized and discussed the influence of fluctuations of temperature on physiological processes. Every genus, and perhaps even every species of fishes, in the course of the early development of its ova, appears to present some idiosyncrasy of behavior which demands that its characteristics shall be studied before it is ventured to proceed with experiments of this character. Practically the peculiarities of the ovum of the shad are perhaps as well known as those of any species we are called upon to deal with.

Shad eggs after impregnation are relatively large, measuring from one-eighth to one-seventh of an inch in diameter. When first extruded

from the parent fish they measure about one-fourteenth of an inch in diameter, are somewhat flattened and irregularly rounded in form; the egg-membrane, a true *zona radiata*, is much wrinkled and lies in close contact with the contained vitellus. Immediately after impregnation this membrane becomes tense, is filled with water which has found its way through the membrane from the outside, and is now perfectly spherical, having apparently gained very much in bulk. This gain in size is however delusive; it is only the wrinkled egg-membrane which has been distended with water; the vitellus or true germinal and nutritive portion has gained nothing in size. The latter now lies in contact with the lowermost part of the egg-membrane when the whole ovum is at rest and is always more or less depressed from above in the form of an oblate spheroid. After the germ has been developed, which is discoidal in form and placed on the surface of the vitelline sphere, it usually also occupies a lateral position on the vitellus when the ovum is at rest. The vitellus rolls about and changes its position inside the egg-membrane as the latter's position is altered. The vitellus is heavier than water. A large space filled with fluid now exists between the vitellus and membrane. No adhesive material is found on the outside of the membrane as in the eggs of the white perch and herring, as may be readily demonstrated with the microscope, although when first extruded they are covered with a somewhat sticky ovarian mucus. The ova are heavier than water and rapidly sink to the bottom of the vessels in which they are undergoing development. All of the hatching apparatus now used for their incubation in water is operated on the principle of a continuous flow which keeps the ova constantly in motion. So much for the physical behavior and constitution of the shad egg, which is necessary for the comprehension of what will be said subsequently.

It has been the experience of those intrusted with the work of looking after the artificial incubation of the eggs of the shad that when the temperature of the water was highest the process was completed soonest, when lowest it took a disproportionately longer time. In illustration of this fact the subjoined data, supplied by Mr. W. F. Page, are of interest from the records which were kept at the station on the Potomac during the present spring (1881):

	Lot No. 1.	Lot No. 2.	Lot. No. 3.
Time in hatching	148 hours.	109 hours.	70 hours.
Average temperature of water	57. 2° F.	64. 5° F.	74° F.
Average temperature of air	61° F.	66. 1° F.	76. 25° F.

This series of data shows that with a fall in the temperature of the water down to 57.2° F. it took six days and four hours to complete the development in the egg; with a rise in the temperature of the water to 74° F. the process was complete in a little less than three days. The difference in the times of hatching between Lots No. 1 and 3 is 78

hours; the difference in the temperature of the water used is only 16.8° F. Is there a limit to the possibilities of retardation? Experiment has shown that there is. The temperature of ice-water, 38° F., was found to be fatal at the morula or germinal disk stage of development of the shad egg, in the course of experiments made at Havre de Grace, Md., in 1880. The cells of the germinal disk became brownish, the cleavage furrows obliterated, the disk tended to spread out and become larger across. These phenomena indicated stagnation of development and death. The second series of experiments, conducted by what is known as the "dry method" in a refrigerator box provided with canton-flannel trays, devised by Mr. F. N. Clark especially for these experiments, gave better results. We found that the ova merely kept damp on the trays in an air temperature of 52° appeared to develop quite normally, the only serious drawback being the rapid and more or less fatal development of fungus, the mycelium of which would soon grow over the eggs, penetrate the membranes, cause them to collapse, transform the protoplasm of the vitellus into fungus protoplasm and kill the ova.

The following abstract from my note-book, recording what was observed in watching the results obtained from a trial of Mr. Clark's apparatus, speaks for itself, though it would facilitate the comprehension of the matter if a series of explanatory figures could be introduced:

"Eggs taken June 8 and put into refrigerator at 9 o'clock p. m.; examined June 9 at 9 o'clock a. m.; exposed for 12 hours to a temperature ranging from 54° to 60° F. Cleavage has advanced to the morula stage; *i. e.*, the germinal portion of the egg is still discoidal, lies on one side of the vitellus or yelk, and has not advanced beyond the condition ordinarily reached in three hours with the temperature 72° F.

"Same lot, June 9, 2.30 p. m., not advanced but a little beyond the stage just described above; the germinal disk still maintains its characteristics; development normal; temperature 54° F.

"Same lot, June 10, examined at 9.30 a. m.; segmentation cavity developed and blastoderm forming; incipient embryo making its appearance at one side. The blastoderm, however, does not yet cover more than half of the upper hemisphere of the vitellus, a condition ordinarily attained in six hours with the temperature of the water at 72° F. Temperature in refrigerator box now ranging from 52° to 54° F. Eggs of the same age, 36½ hours in a hatching-jar, have the vitellus completely inclosed by the blastoderm, the embryo formed, with eyes, ears, and brain distinguishable, and the tail is budding out as a small, rounded knob at the posterior end of the embryonic axis, which curves around one side and now extends from one pole of the egg to the other, embracing an arc of 180°.

"Same lot, in refrigerator, examined June 10, at 8.30 p. m., or nearly forty-eight hours after impregnation, show that the blastoderm has grown down half way over the vitellus, like a hemispherical cap; the

keel or carina has been developed. Temperature 53° F. in refrigerator all day. Eggs in a cone of the same age, temperature of the water 65° F., have the embryos well advanced, with the tail free and as long as the portion of the body still in contact with the yelk, but the natatory fold is not developed.

"Eggs which had progressed a considerable way in development, so that the tail was somewhat more advanced than the stage last described, and which did not yet have the eyes pigmented, were also experimented upon at this time. In consequence, it was learned that such might be suddenly transferred from the water in which they had previously been undergoing development to the damp cotton-cloth trays without injury from such sudden and continued exposure to an air temperature of 53° F. A most striking fact was that in such as had the choroid or pigmented coat of the eyes in process of development had the formation of the pigment arrested in correspondence with the general arrest of development observed.

"Returning to the eggs of the 8th June: These were examined June 11, 9 a. m. Development is still normal; the eyes are perfecting, but the perfectly normal blastoderm does not yet quite cover the vitellus, the diameter of the opening at the caudal pole, where the vitellus or yelk is still exposed, being equal to about one-seventh of the circumference of the egg. Temperature during the night, 49.5° F.

"Other lots of ova, taken on the 6th and 7th June, and removed from the hatching-cones and put on the cloth trays in the refrigerator box, have been greatly retarded, but the development is normal, no abnormalities whatever having been observed. The lot, taken on the 8th and put into the refrigerator on the 9th, after having been in the water for 24 hours, are well advanced, the tail being twice as long as the portion of the embryo's body attached to the yelk, and the fin-folds are nearly fully developed, dorsally and ventrally.

"The eggs first put into the refrigerator on the evening of the 8th June now show a disposition to wrinkle, *i. e.*, part with the water inclosed between the egg-membrane and the vitellus, and are collapsing. Perhaps this is due to evaporation." Afterwards I abandoned the view that evaporation was the cause of the collapse and wrinkling of the egg-membranes. I am now fully convinced that it was due to the invasions of a fungus.

"Same lot of eggs of June 8 examined June 11, at 7 p. m. Blastoderm not yet quite, but very nearly, closed over the vitellus. Only a very small round opening at the tail of the embryo marks the point where its closure is about to take place. Temperature, 53° F. in refrigerator. Development normal in those which are not collapsing, after remaining 70 hours on the trays.

"June 12, 11 a. m.—Eggs of June 8 in refrigerator for the most part still alive. Temperature, 52° F. Development has been normal up to this point; the blastoderm has closed over the vitellus, and the tail is

just beginning to bud out as a rounded knob, as in 24 to 36-hour embryos hatched in water ranging from 80° to 72° F.

"Eggs of June 7, partially developed, have commenced to collapse in the refrigerator box. This appears to be due to the growth of the fungus on the ova.

"June 13, 10 a. m.—Examined the eggs put into the refrigerator on the night of the 8th. They are now nearly all dead. Those not affected with fungus mycelium still plump, and normal in development; caudal knob, but a little more prominent than when examined on the 12th, at 11 a. m. Temperature in box, 53° F."

We may sum up the result of these experiments as follows:

After a little more than four and a half days the ova of the shad exposed on cloth trays to a temperature of about 52° F. have not advanced farther than they would have done in water at a temperature of 80° *F. in* 24 *hours, or in* 30 *to* 36 *hours in water at a temperature of* 74° *to* 68° *F.*

But after four and a half days our embryos have not yet passed through half of their development, so that it would be safe to say that the period of incubation at this rate could be prolonged for nine days, or a period long enough to readily admit of the transportation of ova, so retarded, across the Atlantic to England, France, or Germany. The bar to our complete success, however, was the rapid and fatal development of the fungus, which is probably a saprolegnious form identical with the one commonly productive of more or less loss in hatching out ova in water in all the forms of apparatus which I have seen used. If attention were directed to a means of destroying the germs of these organisms I think success might be very confidently anticipated. To effect the complete destruction of the spores in the water used, and to prevent their ever coming into contact with the eggs upon which they lodge, germinate, and grow, are the preventive measures to be adopted. These measures are, I believe, feasible, but may involve some trouble in their execution. The experiments of Tyndall and Pasteur have taught us that it is possible to sterilize any fluid and render it absolutely free from all forms of organic germs by energetic boiling, taking care afterwards to exclude the germ-laden air by means of stoppers of cotton wool, or by hermetically sealing the vessel. Such a method would, of course, not answer in this case, as in sealing up a vessel containing the eggs in sterilized water they would be smothered. The precautions which are practicable, however, are these: (1) Take care to scald and thoroughly sterilize the pans into which the fish are spawned; (2) take care to wipe the spawning fish clean, and, above all, avoid rubbing off the scales or to allow these to drop into the spawn or milt; (3) use only sterilized water to "bring up" or water-swell the eggs; (4) take care to scald out the refrigerator and cloth trays, so as to sterilize these of any germs; (5) it would also be necessary to boil and sterilize enough water to keep the eggs and cloth trays moist during the process of retardation; (6) the sterilized water should be kept tightly covered in a clean vessel; (7) in managing the refrigerator care should

be taken in opening and closing it, and, in order to ventilate it, the opening in the upper part of the chamber for the admission of air should be provided with a filter of cotton-wool; (8) it would be necessary to scald and sterilize new cotton cloths, since these are almost always laden with germs. These precautions, observed with scrupulous care, would insure success, as far as the danger from fungus is concerned, in conducting this mode of retarding development.

The second series of experiments were conducted at Washington in association with Colonel McDonald, this gentlemen having kindly undertaken to aid in the work of experimentation, by means of various ingenious forms of small and convenient hatching apparatus, of his own devising, mostly made of glass. The method pursued consisted partly in treating the eggs for some time on the dry principle on trays, completing the incubation afterwards in the glass apparatus fed with water from a coil of tin pipe kept under ice in a refrigerator; this enabled us to maintain the temperature of the water supply at a pretty constant point, ranging from 60° to 63° F. It was necessary, on account of the distance which the eggs had to be transported, to use trays covered with damp cloths on which the impregnated, water-swollen ova were carried in transit from the spawning grounds. The experiments were conducted in the basement of the Smithsonian Institution, where some of the trays of eggs were placed in a refrigerator and others put directly into the water at the temperature stated above, using the McDonald apparatus. The results of these experiments were of great interest and of considerable value, as giving us data for certain precautions to be observed in the conduct of future work and experimentation, as may be learned from the account of them which follows.

Colonel McDonald found it necessary to devise some ready means of transporting the ova from the spawning grounds over a score of miles down the Potomac from Washington. This necessity, for an expedient, proved that the transportation of ova by the dry method immediately after they had been water-swollen was possible, and that it would answer for long distances. To illustrate: some were kept on the trays in good condition for seventeen hours in the ordinary temperature of the air, of 70° to 80° F., prevailing at that season of the year (July). When the temperature of the air was up to 90° F. it was found that the ova carried on trays and allowed to remain on them would tend to spoil quickly, as *bacteria* and *vibriones* were distinguishable on all the spoiled putrescent ova carefully examined under the microscope. It is therefore evident that in warm weather, in transporting ova by the dry method for long distances, it would be necessary to take certain precautions to prevent the access of the germs of such putrefactive organisms to the eggs. Essentially the same method of procedure recommended to guard against the introduction of the spores of the saprolegnious fungus to the eggs would apply here. Such precautions, however, would only be necessary where it was desired to retard the development for a

long time, in case it was desired to transport the ova long distances. I think it would be found practicable to carry eggs on trays on damp cloths for a period of 24 to 48 hours without the least difficulty, provided a refrigerating apparatus was constructed in which the temperature could be kept at 60° to 65° F.; below this temperature it would not be safe to go, for the ordinary purposes of transportation from the spawning grounds remote from the hatching stations. An important matter to attend to in the application of the above plan will be to effectively scald the cloths which are laid in the trays each time before they are again used, or else they will become the nidus of untold myriads of putrefactive germs which will lodge from in the air in dust, the retention and development of which would be favored by whatever of mucus, dead eggs, egg-membranes, and blood might adhere to the cloths from one time to another.

The putrefactive germs always liable to be conveyed in the impalpable dust constantly suspended in the air of houses in this latitude are consequently much more insidious in their approaches than the germs or spores of the saprolegnious fungus, which ordinarily causes a considerable loss of eggs in the hatching-cones. The eggs attacked by the fungus in the water first turn white; the egg-membrane then shows a disposition to wrinkle or become flaccid; the mycelium or growing stage of the fungus is now in active progress. The mycelium is simply a felted meshwork of branching fungus cells, which appropriates the substance of the egg and completely envelops its membrane. In this stage it is comparatively harmless; afterwards from the felted mycelium threads club-shaped cellular prolongations grow out, which radiate in all directions like the seeds on a dandelion seed-head. In time each one of these club-shaped heads of the fungus, to the number of hundreds on every affected egg, develop a large number of spores or germs on the inside; directly the end bursts open and the minute spores swarm out of the club-shaped spore-case in great numbers. Each of the spores is capable of independent movement by means of long vibrating filaments attached to it at one end. These wander about in the water, lodge on healthy eggs and grow on and destroy them, so it is important that infested eggs should be removed as soon as they make their appearance in the hatching apparatus. Kühne and Cohn have shown, however, that a temperature of 140° F. is sufficient to kill the germs of *bacteria* and other putrefactive organisms, and it is very likely that such a temperature or less than the boiling point of water, 212° F., would be quite sufficient to clear off and kill any fungus germs which might adhere to the pans, trays, and cloths used in the transportation of ova.

The preceding account of the development, destructive growth, and maturation of the spores is from personal observations made on eggs infested with fungus in the hatching-cones on the barges at Havre de Grace in 1880, and it is only introduced here to direct attention to some possible means of staying or mitigating its ravages. I do not pretend

to know the species by its botanical name. I leave its identification for the cryptogamic botanists; practically, a knowledge of its life-history suffices for our purposes.

The following record of the most salient features of my observations, made in association with Colonel McDonald, is on the whole not as encouraging as the experiment made at Havre de Grace, but it is of value on account of the pathological changes or deformities which it was found were induced in embryos when they were subjected to too low a temperature. Only in the very late stages did they appear to be comparatively free from this influence tending to the production of deformities.

A lot of eggs which had the germinal disk biscuit-shaped and normally developed were placed on trays in the refrigerator in the evening, in an air temperature of 45° F.; they were found in apparently normal condition after 24 hours had elapsed, but had made little or no progress in development. After 24 hours more, or after exposure for 48 hours to an air temperature of 45° F. on damp cloth trays, the germinal disk was found to be deformed and dead, being helmet-shaped, with one or two constrictions or furrows running round it; the vitellus or yelk still retained its normal appearance, however, the vitelline spheres being clear, with the protoplasmic mesh-work enveloping them in a normal way. Of the same lot, those which were taken out of the air temperature of 45° F. and put into water at 74° F., hatched out normally in a good percentage without deformities, showing that a sudden transfer to water at a much higher temperature was not attended with difficulties. The prolonged stay of 48 hours of the same lot in the refrigerator at 45° F., showed that complete arrest of development and death would supervene, and that a profound abnormal change in the form of the germinal disk would result.

Another series of experiments with eggs kept in a temperature of 64° F. showed the same tendency to retard development as was shown by the Havre de Grace experiments; embryos of the same age in water at 74° F. developed nearly twice as rapidly.

Other experiments showed that eggs which had been retarded in development at a temperature a little below 52° F. for two days exhibited a tendency to develop abnormally. The abnormal phenomena which were noticed principally affected the notochord or embryonic axial cartilaginous rod, which had a tendency to become bent and twisted, while constrictions were also apt to appear giving it an irregular beaded and generally misshapen appearance. Such deformities seemed to affect only the caudal portion of the notochord; the portion toward the head end of the embryo being normal in its appearance. In this way great deformities of the tail arose, so that in a micro-photograph of an embryo two-thirds developed, the tail, instead of being gracefully bent flatwise to one side, is abruptly bent downwards and then upwards, so as to be approximately V-shaped, as seen from the side.

Sometimes the deformation of the tail would only be noticeable at its

extremity; at others, the deformed portion of the notochord would extend some way forward over the yelk beyond the point where the tail originated, as it budded out from above the point where the blastoderm closed. In no instance was it observed that any deformity or disturbance of the structure of the yelk took place, or that the epiblastic or hypoblastic coverings of the latter were distorted.

The epiblastic coverings of the tail, however, showed a tendency to crumple and become distorted. It was also commonly noticed that the epiblast showed a tendency to proliferate or throw out masses of cells in the form of irregular knob-like clusters. These increased rather than diminished in size as development progressed. No other structure of epiblastic origin took part in the tendency to become misshapen. The eyes, nasal pits, and ear capsules were normal in every respect. The heart pulsated more slowly than in embryos hatched in water of the usual temperature. This was probably due to the benumbing effects of the low temperature.

When deformed embryos were transferred to water of 74° F. they showed no signs of regaining their normal shape, but, on the contrary, the deformity seemed rather to be aggravated as development proceeded. This was the case also when transferred to water ranging from a temperature of 60° to 64° F. Once established, any deformity in development seemed irremediable by any further stages which might be necessary to complete the developmental processes undergone in the egg.

In the light of these researches, taken in their entirety, it would therefore appear that 55° to 53° F. is about the limit to which we can with safety reduce the temperature in which the ova of the shad will undergo their normal development. This temperature would give us, approximately, nine days as the longest period of incubation attainable, time sufficient added to the 4 days required for the young to absorb the yelk-sack, or 13 days in all, to take embryos to be incubated on the route all the way across the Atlantic, or even as far as the Danube or Black Sea. Even this period may be somewhat extended, since it is possible to retard the absorption of the yelk-sack of the young fish by keeping them in water of 60° to 65° F. A temperature of 55° F. would probably not be injurious at this stage. I have kept the young in water at 38° F. for half an hour without apparent injuring. They had been hatched only a short time before. The cold would benumb them, and they would lie quietly at the bottom of the vessel until restored to activity as they were warmed up in water of over 70° F., to which they were at once transferred without harm. The muscular masses at the sides of the body were benumbed as indicated by the quiescent behavior of the embryos. Tissue metamorphosis would be hindered by such a fall in the temperature of the water. We saw that the cold caused the pulsations of the heart to diminish in rapidity. This abatement in the activity of the forces concerned in the transformation of the stored

protoplasm of the yelk into the structures of the growing embryo would be very marked in consequence of subjecting young shad to a temperature of 55° F. By this means, reasoning from what we know of the other phases of development when exposed to like temperatures, the absorption of the yelk might be retarded so as not be completed for six or seven days. This would give us, added to the maximun period of incubation of nine days at 53° F., a total of fifteen days, a period certainly long enough for all practical purposes in the transportation of young fish for stocking purposes.

I would seize this opportunity to remark that it must, however, be borne in mind that the growth of an embryo in the egg is different from the growth of the young animal after it has been hatched and begins to feed. The fish embryo has a store of food, which is inclosed in the yelk-sack, which can scarcely be said even to be transformed, it only suffers a change of place, as particle after particle of the yelk substance is removed and built up into the structures of the growing embryo. This transfer is effected through the blood, and also by apposition from below. The young growing animal in feeding must truly transform the protoplasm which it eats; it must digest it; it is carried into the blood as chyle, and so to all parts of the body to repair the waste incident to the exhibition of life. The two processes, upon careful comparison, are wholly unlike. A fall in the temperature diminishes the rate at which this transfer of the yelk substance to the structures of the growing embryo takes place. The frequency of the pulsations of the heart decreases, consequently the yelk substance which is in contact with vascular sinuses below the embryo is not taken into the blood as rapidly. The result of all this is that the absorption of the yelk is impeded and made to minister to the development and growth in size of the young fish for a longer period.

A few other points, and I have done with this part of the subject for the present. Most steamships now use fresh water distilled by an apparatus specially constructed for the purpose. This water, provided the most ordinary care was exercised in the storage, would be well fitted to use in the process of retardation. The eggs carried on the trays ought to be occasionally sprinkled with pure sterilized water. The distilled water supplied aboard steamships answers this description fully, and almost everything is accordingly ready to our hands. To reduce the temperature of the water used in the latter stages of development, when it would be necessary to transfer the eggs to water, say on the eighth day, or after they had been for eight days on the damp trays, it would be desirable to avoid contamination of the water from the ice. To avoid this, the water should pass through coils of block-tin pipe, placed in tubs, and kept filled with cracked ice; thus we could lower the temperature to at least 60° to 58° F. The same water might be used several times over, because with care it would be so slightly contaminated with organic matter that putrefactive processes

could not go on to any hurtful extent. The low temperature would also tend to arrest any tendency to putrescence.

How to maintain a uniform temperature in the refrigerators, so as to guard against dangerous fluctuations of temperature, appears to me to be a matter of some difficulty, because sudden meteorological changes, such as we sometimes experience in this latitude, would influence the working of the apparatus. The best regulator would probably be a faithful attendant. The control of the temperature of the water flowing through coils surrounded with ice, is, in the light of experience, a comparatively easy matter, as it has been found that in a coil of a given length the fluctuation in the temperature will not vary more than three or four degrees, if a little attention is bestowed in regulating the flow and keeping a good supply of ice packed around the coils.

The prevention of leakage or loss of water from the apparatus would be entirely overcome, both on board cars and steamships, by the adoption of the closed glass hatching-jars, of various forms, devised by Colonel McDonald. They appear to be cheap, and are very economical of room. There can therefore be no objection to the introduction of the apparatus into vessels and railway express cars on the score that it makes objectionable slop and slush on the floors or decks.

The foregoing, it appears to me, is an approximate solution of the problems which we set out to answer; whether we are right another season's work ought to enable us to decide practically and finally, as we can now take up the subject intelligently; the preliminary experimental work has been completed.

APPENDIX ON THE HISTOLOGICAL RATIONALE OF RETARDATION.

Every developing ovum is made up of certain cellular elements, each one of which is provided with a central nuclear body, which appears in the light of recent researches to be the directive dynamic center of all further changes involved in the successive cleavages undergone by the cellular elements constituting that portion of the egg immediately concerned in the formation of the embryo. The assumed disappearance of the nucleus of the egg has been proved not to take place in the act of impregnation, in not only invertebrate ova, but also in vertebrate ones as well. The hypothetical assumption of a cytode or moneron stage of development in the ova of all forms by Haeckel does not, therefore, appear to be sustained by facts. These and other known facts, such as the recent observation of the metamorphoses of the nuclei of Rhizopods in the act of division (multiplication), also throws doubt on the existence of the *Monera* themselves, as Von Hensen has suggested. Nuclear networks inside of cells, as well as intranuclear networks, seem to be of almost universal occurrence according to the researches of Flemming, Klein, the Hertwigs, Pfitzner, Fol, and others on animals and man, and by

Strasburger on plants. Indeed, so strikingly is this true, that Strasburger has been tempted to utter the dictum, *omnis nucleus e nucleo*, which in English means that all nuclei originate from pre-existing nuclei, just as formerly Schwann expressed himself to the same effect in relation to the genesis of cells. Such intracellular granular networks extending outwards from the nucleus through the protoplasm enveloping it may be seen well developed in the coarse vesicular connective tissue cells of the American oyster, of which I have mounted preparations. Vastly more complex intranuclear reticuli are found in the nucleus of the unripe eggs of the common slipper-limpet, *Crepidula glauca*. I have seen the granular threads in these undergoing the most wonderful active changes of form. Spindle-shaped nuclei, the opposite poles of which were joined by granular threads, have been observed in the eggs of Elasmobranch fishes by Balfour. These were in the act of division, or in the diastole condition spoken of by Flemming. Œllacher has seen granular threads radiating from the nuclei embedded in the cells of the germinal disk of the trout in its early stages of development. These nuclear transformations consequently occur in the cellular elements of fish embryos. These observations are further supported by the fact that both Brooks and myself have observed undoubted evidence of the rhythmical nature of segmentation in fish ova, which ought to be the fact, since it has been shown that the metamorphoses of the nuclei are likewise rhythmical in character.

The metamorphoses, or changes in the form and structure of the nucleus, are, in large part, connected with the genesis of new cells, in the successive acts of cleavage or segmentation; their metamorphoses, doubtless, also play an important part in the functions of rejuvenescence and depuration of cells, or in the general functions, repair and waste, as well as in the excretory and secretory functions of organs. But in retardation we have nothing to do with these latter kinds of nuclear metamorphosis; we are only concerned with the alternate elongation and contraction of the nucleus attendant upon the process of segmentation or the fissiparous genesis of new cells, in which the pre-existing nucleus of a cell, about to divide, elongates, becomes severed into two parts, which become, respectively, the nuclei of two new cells. In the process of cleavage it has been shown that, during the act of cleavage, the nucleus of the cleaving cell elongates, becomes spindle-shaped; that the opposite poles of the spindle become, respectively, the nuclei of the two new cells resulting from the completed process of segmentation. During the active stage the two poles of the spindle are joined by a barrel or spindle-shaped series of granular threads. When the segmentation is about to be consummated, these threads, half way between the poles, are found to have developed nodes or swellings; these mark the point through which the segmentation furrow will pass, so as to separate the old cell into two new ones. The segmentation furrow, accordingly, passes at right angles across the long axis of the spindle-shaped

nucleus. As soon as the segmentation has been effected the granular threads are withdrawn from the nodal points at the place where the segmentation furrow severed them, and are finally retracted into what were formerly the two poles of the spindle. These poles are now the nuclei of the two new cells, and, as soon as the granular threads are withdrawn towards these new polar nuclear centers, the latter become globular and pass into the resting stage. Afterwards they both elongate and go through the same process, as here described, in the course of subsequent cleavages. This alternate elongation of nuclei into a spindle-form, and contraction into a spherical form, in the process of cleavage, has been called by Flemming the *diastole* and *systole* of the nucleus. They accompany the rhythmical phenomena of segmentation and give us a rational and philosophical interpretation of the phenomena of segmentation. It must, I think, be plain to any one that this is essentially a dynamic process, in which the artisan of organization almost makes his methods of work visible.

It also affords a scientific explanation of the phenomena of retardation. Inasmuch as we have lowered the temperature of the air and water, the media in which the ova of the shad underwent their development, and find that it is retarded in consequence, we must naturally conclude that the rate of segmentation, upon which the rate of development directly depends, has been in some way interfered with or impeded in its progress. Since we also saw that the rhythmical metamorphoses of the nuclei were directly concerned in the process of segmentation—that in them the *vis essentialis*, essential force of segmentation, really resides—it appears to me that we are also really bound to conclude that the fall in the temperature has affected the activity of this *vis essentialis* of the nuclei, which are retarded in their metamorphoses, in consequence of which the rate of segmentation and development is retarded. This fully and clearly accounts for the resulting prolongation of the normal period of development when the temperature of the media in which the ova undergo their evolution is lowered as much as is consistent with their regular, healthful incubation.

If retardation is possible, it ought also to be possible to accelerate development. For centuries it has been the practice to accelerate and maintain the growth of plants in hot-houses and forcing pits during inclement seasons of the year. This is proof enough, as far as the vegetable kingdom is concerned, that acceleration of the processes of growth, which simply means that the acceleration of fissiparous cellular proliferation or segmentation is here possible. Its philosophy is the same in principle as that of retardation; acceleration is the converse or reciprocal principle as opposed to the former. According to a table given by Mr. R. E. Earll, in his paper on the development of the cod, in the United States Fish Commissioner's report for 1878, page 724, we learn that the minimum time of incubation for the ova of this fish is 13 days, temperature of sea-water 40° F.; the maximum time, according to

the same authority, is 50 days, temperature of sea-water 31° F. Our own experience at Wood's Holl last winter taught us that the development of the ova of the cod was capable of being accelerated, for those in a glass cone near a warm stove hatched out in a shorter space of time, 16 days, than any others. Our power to accelerate the rate of development of the cod may be of use, as we may thereby be enabled to hatch out a large percentage of ova in a very few days. Whether the young would be as vigorous as those incubated in the natural way remains to be learned.

Acceleration, like retardation of development, is accomplished by influencing the rate of the rhythmical metamorphoses of the nuclei of the cells of the embryo. Accelerate the rate of these metamorphoses and segmentation is hastened so as to cause development to proceed more rapidly. The stimulus is heat, a mode of motion, and we are forced to believe from what has preceded that the nuclear metamorphoses are simply the specific modes of motion of the cellular life centers. The molecules of the nuclear spindles, reticuli, &c., are made to move more or less actively in obedience to the fluctuations in the activity of this external stimulus. All this goes without saying, however, that the protoplasm, which in the case of every cell invests the nucleus, may not also share in the process; it is but natural that it should, because free nuclei, independent of any investment of protoplasm, are unknown to histologists.

Inasmuch as the granular particles of nuclear fibers and reticuli exhibit certain modes of motion which appear to be characteristic in the course of segmentation, and since we find that heat, admittedly a mode of motion, accelerates or retards the motion of living nuclear matter in its segmentational metamorphoses, are we not warranted in assuming both of these kinds of motion to be in a degree correlated and interdependent? The significance of the views here set forth in their bearings upon general physiology and pathology would appear to warrant the belief that we may yet be able to solve some of the knottiest problems in biology. Their practical significance in relation to the problems which have presented themselves for solution to the Fish Commission will also be apparent.

A CONTRIBUTION TO THE DEVELOPMENT AND MORPHOLOGY OF THE LOPHOBRANCHIATES; (HIPPOCAMPUS ANTIQUORUM, THE SEA-HORSE.)

(With one plate.)

By JOHN A. RYDER.

During the present summer Mr. W. P. Sauerhoff captured a male sea-horse of our common American species in the Chesapeake, near Cherrystone, Northampton County, Virginia. It was placed in an aquarium some time in the latter part of July and shortly afterwards over 150 young ones were discharged from its distended marsupium, or brood-pouch. One of these young specimens preserved in spirits and handed to me for investigation is the subject of this notice.

There is perhaps no teleostean fish which is more grotesquely and profoundly modified in structure as compared with the ordinary ichthyan type than the sea-horse, and it is for this reason that its development is of especial interest to students of embryology. To briefly indicate in what particular features it differs most widely from other bony fishes may not be amiss.

The caudal fin has completely disappeared and the tail is not even used as a rudder, as in the pipe-fishes, but has become prehensile and serves the animal to hold fast to slender objects in the water. The usual function of the caudal has been assumed by the dorsal and anal; the dorsal is the principal agent used in propulsion, and with its help the creature sculls along with the axis of its body inclined at an angle of about 45° to the horizon; the sculling action is undulatory and the dorsal border of the fin describes in its movements a figure like the number 8. The anal appears to play the part of a rudder as well as assist in propulsion. The dorsal is also used in the pipe-fishes as the propeller; the body is also inclined when in motion; their behavior in the water indicates that they have not been as highly specialized or have not undergone such extensive modifications as their relative the sea-horse, but that it is probable that both have descended from a common ancestral type. In both the eggs appear to be received and carried about by the males during the period of incubation; in the male sea-horse there is a marsupium or brood-pouch situated behind the anal fin; it is comparatively undeveloped except in the spawning season. In some of the pipe-fishes the eggs are carried by the males in an excavation or groove in the under side of the abdomen extending for some distance in front of the vent, and covered over by wide dermal folds which arise from either side of the lower edge of the body and which lap over each other in the middle line; in others, as in *Syngnathus ophidion*, there is a pouch behind the vent as in the sea-horse. In this space the developing eggs are embedded in a firm gelatinous matrix. Impregnation of the ova probably takes place at the time the eggs are transferred from the female to the male.

The most striking feature of all, however, in the organization of *Hippocampus* is the downward flexure or bend of the head, which, together with the shape of the latter, develops a most marked resemblance of the forepart of the body to the head and neck of the horse, whence the common name of the animal. Accompanying this feature the bones of the snout have been prolonged so that the jaws are carried very far forward, while the latter have themselves not undergone so much modification. The gills and opercular apparatus have also been much modified, the former in the adult consist of four pairs of arches with two rows of pinnate, pyramidal, vascular branchial appendages resting on and attached by their apices to their outer borders; these answer to the branchial leaflets of other forms; the opercles articulate with the hyomandibular behind by means of a distinct articular facet, and are swung inwards and outwards on this articulation. At the upper border of the opercle on either side and behind the auditory structures there are placed the gill-openings, which are almost spiracular, and open upwards, the opercles being attached by their borders all round by membrane, except for a short distance at their upper posterior edges, where the opercular efferent openings are placed. In that the water is forced through the gills by the concurrent action of the opercles, hyoid apparatus, jaws, and spiracular openings, it will be noticed in living specimens that these parts together constitute a much more perfect pumping apparatus than is usually seen in the branchial structures of fishes. The gills are specialized beyond what is usual, as indicated by the term *Lophobranchii;* but this is misleading, as the branchial structures are not really tufted, as may be learned by a careful examination; the inferior and superior branchihyal elements of the branchial skeleton are wanting, according to Cope, and the arches, to the number of four, appear to be less strongly developed than in other young fishes of the same relative age. I can discern but four pairs, as in the adults, in my specimen. The bend downwards of the head involves a bend in the axial structures in the neck. Here the notochord is strongly bent upon itself, as the embryo studied by me clearly shows. The spinal cord also bends sharply downwards just behind the medulla oblongata, as necessitated by the sharp bend in the notochord below it. These constitute some of the most salient differences of *Hippocampus* as compared with other types of fishes. The skeletal and anatomical characters which distinguished the Lophobranchs as an order, are given in the following words by Owen (Anat. Vertebrates, I, 12): "Endoskeleton partially ossified, without ribs; exoskeleton ganoid; gills tufted; opercular aperture small; swim-bladder without air duct. Males marsupial." Cope* defines the order as follows: "Mouth bounded by the premaxillary above; post-temporal simple, coössified with the cranium. Basis cranii simple. Pectoral fins with elevated basis; well-developed interclavicles. Ante-

*Report of State Commissioners of Fisheries of Pennsylvania for 1879–80, p. 118. 1881.

rior vertebræ modified; the diapophyses much expanded. Inferior and superior branchihyals wanting or unossified. Branchial processes in tufts." To this the following may be added as complementary and as serving to extend the diagnosis: Opercle a simple plate; mouth toothless; *opercular membrane persistently roofing over the gill-chambers of the embryos.*

The term Lophobranch, it appears to me, is liable to lead to misapprehension, as the gills are in reality not tufted at all, but can be referred to the ordinary pinnate type commonly found in a great many fishes. Yarrell* observes in a foot-note: "The tufted filamentous gills of the Lophobranchs are compared by Milne-Edwards to the filamentous branchiæ of a tadpole; and Rathke, who has investigated their structure, informs us that each is framed of a short, delicate, ligamentous stem, to which the respiratory processes are attached by repeated doublings of the branchial membrane, the folds widening as they recede from the base, so as to form an inverted cone or club-shaped tuft." Filamentous tufts do not exist in the gills of *Hippocampus*, so that the first part of the foregoing quotation is erroneous; the latter part of it, attributed to Rathke, is correct, except the last word, and in this the German anatomist was possibly misunderstood.

The true state of the case is as follows: there is a median stalk or rachis to which the branchial leaflets are attached in a pinnate manner on each side. The leaflets become larger as you go outwards, so that the pyramidal form of the compound branchial leaflets results; this pyramid is fixed by its apex to the outer side of the branchial arch. These inverted pyramidal branchial structures are disposed in two series, usually four-sided. There is therefore nothing at all in these structures which is not represented homologically in the fish's gill of the ordinary type, since the two series of vascular branchial appendages to each arch in *Hippocampus* are perfectly comparable with the bifurcated vascular branchial appendages of such a form as *Salmo*. There is plain evidence that a process of degeneration has taken place in the branchial apparatus of *Hippocampus;* the arches themselves have undergone reduction in length; the mesobranchial bony elements are reduced or aborted, and the number of vascular appendages is reduced very much below what is usual; the greatest number of pinnate vascular branchial appendages ranged in one row on the posterior margin of one arch of *Hippocampus* is about ten, which is exceeded several times by the number found in *Salmo*, or in many other common genera. The reduction in number of these appendages may have called for the extension of the area of the ultimate branchial lamellæ or pinnæ, which is a marked feature in the gills of the sea-horse. In other forms, as in *Brevoortia*, the ultimate vascular pinnæ on either side of the gill filaments, which are the active agents in respiration, being richly supplied with capillary vessels, are very feebly

*British Fishes, II, 395.

developed. It is really these vascular pinnæ which have been exaggerated in development at the expense of the other portions of the branchial apparatus.

EARLY DEVELOPMENT.

From what I have observed of the early stages of development of the pipe-fish, *Syngnathus peckianus*, and from a study of ova taken from the pouch of a male *Hippocampus* preserved in alcohol, I offer the following approximate account of the early phases of the evolution of the latter, depending upon the former on account of its close relationship for the details not actually observed. This will not permit us to develop more than such points as we are warranted to infer from their close affiliation to each other, but even such will be of value.

The egg of *Hippocampus*, like that of other teleosts, is constituted of a yelk and germinal material. The former is a rich orange yellow in color; the latter cannot be described, as it has not been seen. In *Syngnathus* the yelk is of the same color, and embedded in it superficially and all around it there are deep yellow oil globules.

The blastoderm of *Hippocampus* is presumably formed, as in all other known teleosts, by a gradual growth of the germinal disk over the yelk so as to include the latter. The rudiment of the embryo appears at first at the edge of the blastoderm, and develops for some time like other fishes, such as the shad, cod, or stickleback. A segmentation cavity is developed, which probably persists as I have observed in *Syngnathus*, and a vitelline system of vessels is doubtless also formed as in the latter.

Up to the time the tail is about to bud out from the caudal swelling at the end of the body of the embryo there is nothing observable which would be considered remarkably different from the type of development exhibited by less modified fishes. The tail of the embryo Lophobranch buds out, and does not develop the prominent dorsal and ventral natatory folds so characteristic of the first appearance of the tail of the embryos of the spiny and soft-rayed forms. It results from this, that the tail is extended backwards, as development proceeds, as a simple cylindrical prolongation of the hind portion of the body. There is, after a while, in *Syngnathus* a low fold developed where the dorsal and caudal are to appear, but there is nothing like the wide natatory fold apparent, such as we see in the embryos of *Alosa*, *Gadus*, and *Cybium* of the same age. In *Hippocampus* there is no caudal in the adult, and we may therefore expect to find little or no evidence of a caudal fin-fold at any period of its development.

The yelk-sack, I apprehend, is absorbed in the usual way, there being, in all probability, no direct connection of the yelk-sack with the intestine. The period of incubation in the marsupium, from the fact that development is pretty well advanced when the young leave it, I should think would be not less than twelve to fourteen days.

The peculiar elongation of the snout probably begins before the yelk-

sack is absorbed, just as I have observed in embryo pipe-fishes. There is also in the latter a more decided downward bending of the head as it becomes free from the yelk; we may expect to see a similar state of affairs in the development of the sea-horse. Beyond this stage in *Syngnathus* an unwonted acceleration in the development in the length of the quadrate cartilage, trabecular cornu (rostral cartilage), pushes the rudiments of the inferior and superior maxillaries forwards so as to lengthen the snout at an unusually early period. In profile, the head of the young Lophobranch now bears a suggestive likeness to that of a pug dog.

From what we know of the early development of the medulla spinalis of *Syngnathus*, according to Calberla,* it is at first solid, as I have found in the case of very young embryos of the shad from a study of transverse sections. This is also probably the primitive condition in *Hippocampus*.

LATER DEVELOPMENT.

The specimen of young sea-horse upon which this notice is based had already left the brood-pouch of the male and had been swimming about for a couple of days; its development had accordingly advanced considerably. We will begin our description with an account of the embryonic skeleton, referring to the plate in explanation of the relations of the parts.

Cartilaginous skeleton.—The axial rod around which the bodies of the vertebræ are developed, and known as the notochord *ch*, still persists and extends from behind the pituitary body *py* to near the end of the tail. At its anterior extremity it is much bent downwards just under the medulla oblongata *mo*. Farther back there is a slight bend in it where the basalia, or basal cartilages of the dorsal fin *df*, almost come into contact with it. In the caudal region it is coiled in conformity with the complete turn which is made by the terminal part of the tail. A sheath appears to be developed around the notochord, and rudiments of the vertebral elements have been developed, but they are not yet segmented and distinct.

The skull.—There are no true bones yet developed in the skull, all of the cranial bones are still represented by cartilage. The anterior end of the notochord *ch* is involved in cartilage which arose primitively as the parachordal cartilaginous masses *p* on either side and a little past the end of the axial element. Beyond this the trabeculæ cranii *t* extend forwards under the brain, the space between them at this stage being slight where the pituitary body *py* lies above it. The cartilaginous basis cranii is extended forwards far beyond the eyes as the trabecular cornu, the olfactory organs or nasal pits *na* lying in an excavation on either side, with an ethmoidal cartilaginous septum, *e*, between them The tegmen cranii *tc* is developed upwards and backwards so as to roof over the fore brain *ce*. In front of the olfactory pits *na* the trabe-

* Morph. Jahrbuch III, 1877.

cular cornu is prolonged far forwards into a cartilaginous bar, *rc*, which we may designate here as the *rostral cartilage* on account of its great antero-posterior development. The cartilaginous investment of the auditory capsule *au* is still imperfect. From the sides of the trabecular floor upon which the brain lies, the palato-quadrate elements arise to give attachment to the cartilages of the maxillary and hyoid arches. The metapterygoid cartilage *mt* extends outwards and downwards behind and below the eye to articulate with the very long rod-like quadrate *q*, which articulates at its front end with the rudiment of the lower jaw, Meckel's cartilage *mk*. Above the articulation of the quadrate with Meckel's cartilage a curious bent element, *x*, appears to represent the superior maxillary. Just in front of the expanded upper extremity of the maxillary lies the posterior extremity of the upper labial or intermaxillary element *la*, which is continuous with a similar piece on the opposite side; this intermaxillary bar curves over the anterior upward bend of the rostral cartilage *rc*. It constitutes the skeletal boundary of the upper part of the oral opening *m'*, and is not segmented in the median line so as to articulate with its fellow of the opposite side like Meckel's cartilage of the lower jaw.

The hyomandibular *hm* is not well differentiated from the metapterygoid; in fact, the point where the quadrate and metapterygoid are segmented is only faintly indicated, as might be expected from the intimate unions of these bones in later life, amounting almost to synostosis. The symplectic *sy* is a slender rod somewhat impressed into the quadrate externally at its upper end, and almost continuous at this stage with the hyomandibular. The symplectic, like the quadrate, is seen to be enormously elongated, as compared with its homologue in the normal ichthyan skull of the same relative age.

The skeletal elements of the lingual or hyoid arch are also modified considerably. The ceratohyal *cy* is a flat, oval cartilaginous plate lying against the inner side of the lower end of the hyomandibular and the inner side of the upper end of the quadrate. It articulates at its lower end with the rod-like hypohyal *hhy*. There appear to be no mesial hyal elements at all, which also seems to be the case with the adult, the medial skeletal elements of the tongue being suppressed.

The branchial arches *b' b'' b''' b''''* are present at this stage to the number of four, the same as in the adult, and the lower mesial elements appear to be absent, just as in the case of the hyoid elements. The branchial cartilaginous bars themselves are weak.

Shoulder-girdle.—The breast or pectoral fins, at this stage, have a high basis, as stated by Cope in regard to the adults, where, together with the dermal plates of the throat, a firm pectoral arch or shoulder-girdle is developed in which there is sutural or, at least, inflexible union of the coraco-scapular elements. I have only indicated the outline of this arch in the figure at *cs;* the object was too opaque here to make out the contour of its elements. The lower end is coracoid, and has

already assumed a horizontal position, the apparently scapular portion is vertical; the pectoral rays seem to arise almost immediately from its hinder border. A powerful azygos muscle originates from the anterior border of the coracoids in the middle line which is inserted by a tendon at the point of junction of the hypohyal cartilages, as shown in the figure. This muscle pulls down the hyoids and increases the capacity of the tubular snout, and is one of the effective agents in the function of respiration; the muscle is represented in its contracted state in the figure.

Structure of the unpaired fins.—These consist of the dorsal and anal. The dorsal *df* has eighteen rays, which rest upon eighteen short intermediary basal pieces, *bc*, cartilaginous in structure, and which articulate by a singular series of link-like structures with the cartilaginous interspinous rays or basalia *ic*, nineteen in number. The muscles which move the dorsal from side to side are arranged in eighteen pairs, and run out radially and parallel with the interspinous basalia, to be inserted just where the intermediary pieces join the latter. In adult specimens, the interspinous basalia which are at this young stage nearly in contact with the notochord by their proximal ends, are pushed farther out and become apposed upon and interposed between the spinous dorsal radii springing directly from three vertebræ. The young, therefore, show that the interspinous basalia of the dorsal are at first more nearly in contact with the vertebral axis.

The anal fin, *af*, just behind the vent *v*, has four distal radii unsegmented and hyaline, the same as those in the dorsal, nor are they yet barely more than incipiently cartilaginous in either of these fins. These rest upon four short cartilaginous intermediary pieces, with the same link-like articulations with the interspinous basalia as were noted in the dorsal. The interspinous rays of the anal *ic* are three in number, and are curved towards and nearly in contact with the notochord at their proximal extremities; but in the adult, as the abdomen develops, these are pushed outwards, and between their inner ends and the vertebral axis there is finally a wide interval.

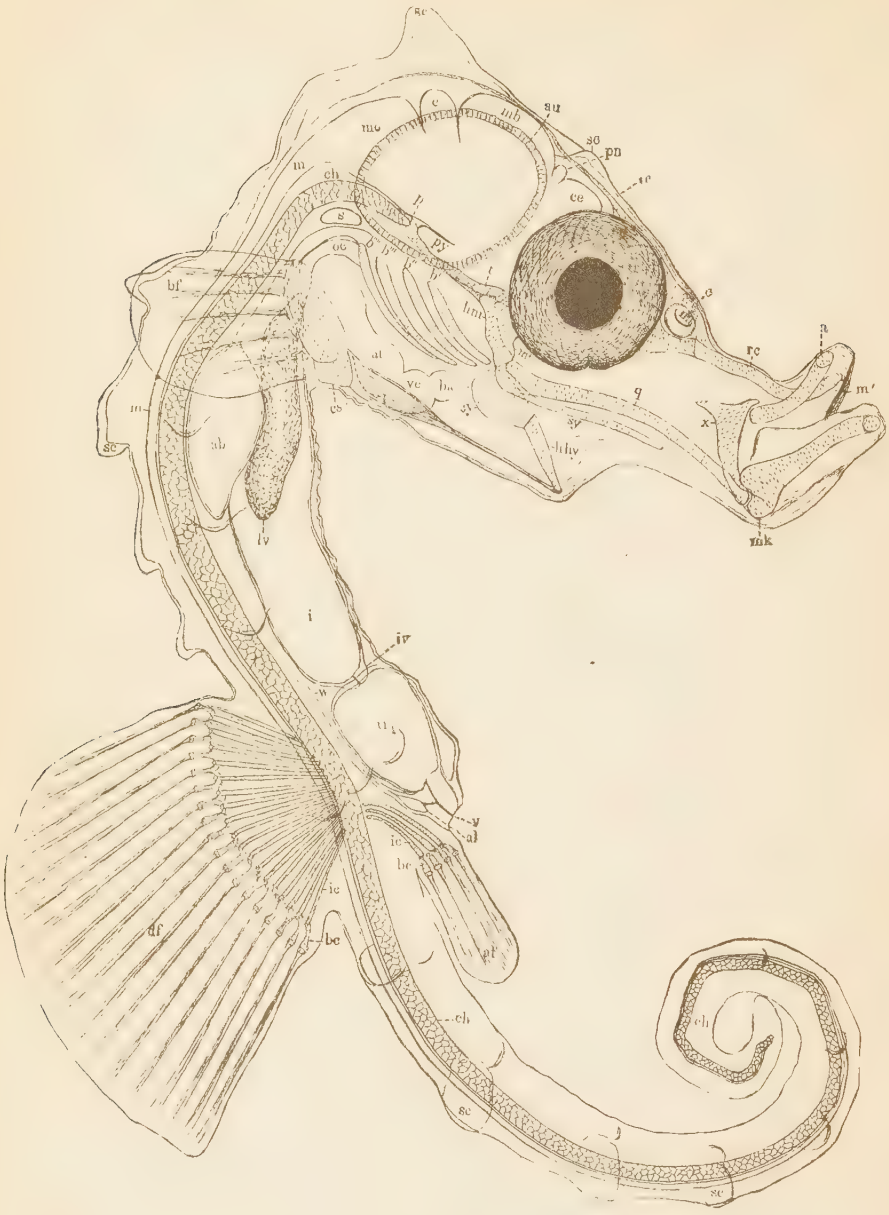
The brain.—Of this there is little to remark, except that its under surface has a direction at right angles to the course of the upper end of the medulla spinalis or spinal cord. The eye is relatively farther forward, as compared with the usual position of the cerebrum *ce*. The eyes on this account are also more approximated than usual, only a very thin interorbital septum separating them, behind which the cerebrum terminates.

Alimentary canal and appendages.—The oral cavity is disproportionately prolonged on account of the length of the intermediary elements of the lower jaw and the length of the trabecular rostrum, and extends from the point *m'* to the pharynx or gill-chamber. The gill-chambers communicate internally in the usual way by clefts with the pharyngeal portion of the alimentary canal. They are essentially closed cavities, except where the interbranchial spaces communicate with the throat,

and where the opercular efferent opening *s* is situated behind the auditory capsule. At this point I would call attention to what I believe to be an important embryological character which appears to distinguish Lophobranchiate embryos from those of the normal types of fishes. It is usual to find the gill-openings of embryo fishes more or less uncovered when they first appear. That is, the opercular fold is often so short as to scarcely cover more than the first cleft; this is a very marked feature in Clupeoids, such as the shad, but is less marked in all other types which I have observed. In the Lophobranch embryo the superficial epiblastic layer, which roofs over the gill-chambers, is apparently never broken through until late, and at no time do the clefts and arches come to be completely exposed as in the young shad. The opercular opening appears late as a mere spiracle, and not as in other forms is the opercle developed from before backwards. The simple opercular plate of the Lophobranchiate embryo probably originates as an outgrowth from behind the hyomandibular bone from a tract of mesoblastic tissue, which appears comparatively late, since the opercle is not yet developed in the stage represented in our figure. Of course we cannot yet be sure as to the value of this character until we know more of the development of other forms. The remarkable manner in which the operculum of *Gambusia* is developed warns us to be cautious in putting an estimate upon such features, for here a hollow membranous process from the yelk-sack extends up over the opercula, a feature quite as singular as that noted in the Lophobranch.

There is a sharp bend in the œsophagus *oe*, and a little way below this bend the alimentary canal suddenly widens. Dorsally and about on a level with the middle of the pectoral fin the spacious air-bladder *ab* arises as a diverticulum from the intestine; its connection with the intestine is closed very early. In front of it and at one side the liver *lv* is developed, but I have not been able to make out where it joins the intestine, which, for well-known morphological reasons, it must do; it is therefore represented only in outline.

Nearly opposite the commencement of the dorsal I find a very singular valve in the intestine at *iv*. Nothing comparable to this structure has been observed in fish embryos as young as this except by myself in the posterior portion of the intestine of the larval cod (*Gadus*), but in that form it is only a constriction, and does not completely shut off the anterior portion of the alimentary canal from the posterior. Beyond this valve the intestine of the young *Hippocampus* is continued as a pyriform rectum ending in the vent *r*, around which the rudiment of the sphincter ani muscle is apparent, through which the ano-cloacal canal passes, receiving dorsally a duct from the urinary vesicle or bladder *al*, into which the segmental ducts *sc* of each side empty their products. The extent of the development of the segmental ducts and mesonephros or kidney could not be made out from my mounted specimen; this can only be done by the help of transverse sections.



HIPPOCAMPUS ANTIQUORUM, *the Sea Horse.*

The dermal plates are regarded as ganoid by Owen. They appear to me to be of sub-epithelial origin, as they are covered with an epithelial layer of cells in the young, which persists in the adult, as in the case of the outer covering of the scales of true ganoids (*Lepidosteus*), where there is a very thin, soft external organic investment. They are somewhat irregularly conical in the young on the fore part of the body, as shown in section on the head and back at *sc*. They are thickest at their apices, and probably grow in thickness from below. On the top and front of the head there are two pairs, on the back four pairs, on the sides of the body one row of three on each side, and a transverse row of three on each side in front of the dorsal; behind the dorsal on the tail, there are first two rows of four and then one row of two, so that it is clear that a good many must be added to make up the number of plates observed to cover the adult. The ventral row found on the adult is absent in the young. Altogether there are more than three times as many plates developed on the full-grown adult male of the same species as are found in the young of the age here described. How these are added can only be learned by further study of more material representing a greater number of stages.

EXPLANATION OF PLATE.

Young *Hippocampus antiquorum* viewed from the side as a transparent object, enlarged 43 times.

ab, air bladder; *af*, anal fin; *al*, urinary vesicle or bladder; *at*, venous sinus; *au*, auditory capsule; b', b'', b''', b'''', first, second, third, and fourth branchial arches of the right side; *ba*, bulbus aortæ; *bc*, basiradial cartilages; *bf*, breast or pectoral fin; *c*, cerebellum; *ce*, cerebrum; *ch*, chorda dorsalis or notochord; *cs*, coraco-scapular arch; *cy*, ceratohyal cartilage; *df*, dorsal fin; *e*, inter-nasal cartilage; *hhy*, hypohyal cartilage; *hm*, hyomandibular cartilage; *i*, intestine; *ic*, interradial cartilages or basalia of fin rays; *iv*, intestinal valve; *la*, labial or inter-maxillary cartilage; *lv*, liver; *m*, medulla spinalis or spinal cord; *m'* mouth; *mb*, mid-brain; *mk*, Meckel's cartilage; *mo*, medulla oblongata; *mt*, metapterygoid cartilage; *na*, nasal pit; *œ*, œsophagus; *p*, parachordal cartilage; *pn*, pineal gland; *py*, pituitary body; *q*, rod-like quadrate cartilage; *rc*, rostral cartilage or prolongation of the trabecular cornu; *ri*, rectal portion of intestine; *s*, spiracular outlet of the gill-chamber; *sc*, dermal scutes or plates; *sy*, elongated symplectic; *t*, trabeculæ cranii seen from the side; *to*, tegmen cranii; *v*, vent or anus; *ve*, ventricle of heart; *w*, Wolffian or segmental duct; *x*, supra-angular cartilaginous element, the rudiment of the supra-maxillary.

ON THE HABITS AND DISTRIBUTION OF THE GEODUCK, A CLAM OF THE PACIFIC (*Glycimeris generosa*, Gld.), WITH SUGGESTIONS AS TO ITS INTRODUCTION INTO THE ATLANTIC COAST OF THE U. S.

(See page 21.)

By HENRY HEMPHILL.

DEAR SIR: I have your favor of September 30, making inquiries in regard to *Glycimeris generosa*, Gld., as to its value as an article of food, and the possibilities of acclimatizing it on the Atlantic coast, &c.

In reply I would say, I think it would be a most desirable addition to our list of edible clams, first, on account of its large size, and, second, for its delicacy and rich flavor, which, when it became generally known, I do not hesitate to say, I think would make it more highly prized than any other bivalve. Unfortunately, however, it seems to be quite rare, although it has a wide range upon our coast. I have collected it in Puget Sound, near Olympia, and here, in San Diego Bay; it is also said to be found near San Francisco Bay, and it is very probable that it exists in all the intervening bays and points where favorable conditions are to be met with. Its variety, however, may be more apparent than real, as its habits and the conditions under which it lives are such as to make it difficult to find, and when found, it is obtained only by hard labor during extreme low tide. Its station, both in Puget Sound and San Diego Bay, is about the same, at extreme low tide. At Olympia I noticed the siphons of several individuals protruding above the surface of the bottom in about one fathom, and it is not improbable that it ranges to much greater depths. In both places it also selects about the same kind of bottom to burrow in, namely, muddy sand, generally free from gravel. It burrows about 2½ or 3 feet below the surface. It can be found only when it protrudes its pipes above the surface, after the tide has run out. The receding tide fills up the holes made by the siphons with sand and mud, and if they did not move them it would be impossible to find them. The specimens I collected in Puget Sound were much larger than the specimens I collected in San Diego Bay, and it may be possible that the cooler or northern waters furnish more nutritious or more abundant food than the warmer or more southern stations. On account of its large size, thin shell, and rich flavor, it may be eagerly sought after by many marine animals, and that matter should be taken into consideration if an attempt is made to colonize it on the Atlantic side. The largest specimens I have seen would, I think, furnish about one pound or more of good delicious flesh, enough for four or five persons to eat at one meal. I think its flesh too rich to permit of regular stuffing or gormandizing, although I ate quite heartily of it for several successive meals, and experienced no bad or disagreeable sensations afterwards. I think it would be esteemed more as a delicacy than a regular every-day diet. I can see no good reason why it could not be acclimatized on

the east coast. From its wide range on this side, I think it capable of readily adapting itself to almost any ordinary conditions, and it is very probable that many localities can be found on the Atlantic coast just as favorable for its development and existence as occur within the limits of the twelve or fifteen hundred miles of its range on this side. Puget Sound would be the best place at which to secure specimens. It is very rare at San Diego. I have not found a dozen specimens during the several years I have collected here, while at Olympia three men could secure a dozen at one low tide or in one day. The greatest difficulty to overcome in attempting to colonize it on the east side would be found in the long time it takes to cross the continent and in having it reach its destination in strong and vigorous condition, so that it would be able to struggle successfully with any difficulties that might occur in its new home. Since receiving your letter I have thought that point over, and the following has suggested itself to my mind as probably the best plan that could be adopted to insure success: Have galvanized iron tanks made, two feet square and three feet high; have strong handles attached so that they could be moved without jolting or jarring; attach a faucet, say, one foot below the top to draw off the water when necessary. Cover the bottom of the tanks with muddy sand, say, six inches deep; place the specimens on the sand in their natural positions, siphons up; then fill in again with the muddy sand, covering the specimens about one foot deep; then fill the tanks to the top with sea water. Draw off the water once or twice every twenty-four hours, letting it remain off, say, half an hour each time, so as to keep up the natural conditions as nearly as possible. A supply of sea-water would have to be taken along, while crossing the continent on the cars, and this should be carried in galvanized iron tanks or tin cans, as water remaining in wooden vessels, barrels, &c., for several days becomes more or less charged with acids which might prove destructive to the animals and defeat the plan. Having selected a place for the colony, dig down, say, eighteen inches and place the specimens in their natural positions, siphons up, then fill in around the specimens, and drive a stout stake near each one, noting the distance and direction, so that they could be easily found when desirable. They should be closely watched for several successive tides, and observations made on their movements, &c. This method would be quite expensive, but it is the only one that has occurred to me which I think would prove successful. The shells are large, and the length of time it takes to cross the country would prove destructive, if they were kept out of the water so long. I believe this covers about all the information I can give on this subject, and if it will serve any scientific purpose, or add to the knowledge of these lowly animals, I shall be much pleased.

San Diego, Cal., *October* 17, 1881.

NOTES ON NEW ENGLAND FOOD-FISHES.

By S. J. MARTIN.

GLOUCESTER, MASS., *October* 26, 1881.

DEAR PROFESSOR: I thought I would write a few lines in regard to the herring fishery.

The herring fishery is over. I find there is some time between schools of spawning herrings. The first gravid herring were caught at Pemaquid, Maine, September 3. The next were taken at Wood Island, September 25. The next, at Rockport, October 3. The next, at Norman's Woe, October 5. The herring were all done four days. When a school struck at Jane's Cove, the herring were full of spawn from the first to the last. The last school caught at Jane's Cove was October 18. They were not so large as the first. They were full of ripe spawn. One thousand barrels have been caught around the cape. Three-fourths went to Portland. The mackerel fishing is fast drawing to a close. The most of the mackerel caught the last week were caught in the night. They are easier to catch in the night than in the daytime. Some vessels got a school last night. I think the sperling (young sea herring) will be scarce this fall. There were plenty of them in September. They all left the river. The fishermen are getting their nets ready; they will set them the last of the month. Hake are plenty on the shore-grounds. The fall school of pollock appeared last week. Some of the Gloucester vessels have made larger stocks this season; I will tell you the largest when fishing is ended.

I remain, your obedient servant,

S. J. MARTIN.

Prof. SPENCER F. BAIRD,
Smithsonian Institution, Washington, D. C.

DESCRIPTION OF THE FISH-WAY IN PITT RIVER, CALIFORNIA.

By S. R. THROCKMORTON.

SAN FRANCISCO, *October* 22, 1881.

DEAR SIR: Your esteemed favor of the 24th ultimo reached me by due course of mail; but confinement to my room by sickness preventing my adding to my information some matters pertaining to the construction of the stone fish-way on Pitt River, I have not been able to reply at an earlier date.

The contract price of the work was $2,400, and it was completed and turned over to the State for that sum, the work having been well done, and complying with all the requirements of the contract.

Outside of the contract we incurred the additional expenditure of

some $300 for engineer's charges, printing, advertising, &c., making in all the sum of, say, $2,700 the entire cost. The rock is of slate, the strata leaning with the current. The conditions were all favorable. The fish-way is made on the southerly side of the stream. The principal weight of the water flowing along the northerly side, the southerly side was easily laid bare by a wing-dam, projected from the southerly bank at a sufficient distance above the fall and at such an angle as to deflect the current to the northerly shore. This mode of exposing the beds of rivers, as practiced by the California gold miners and prospectors, is quite inexpensive, and, at the same time, answers its purpose most thoroughly.

The wing-dam is usually made of long logs secured together so as to form a narrow crib or frame, one end of which having been secured to the bank, the other is swung out into the stream and anchored at the proper angle, when it is filled with sand-bags, brush, sods, and other material, and is very easily made perfectly water-tight. This is continued and extended in the same manner until the part of the river bed to be laid bare is entirely brought within the angle.

If there remain within the angle any pools of water they are baled out, and if any leakage, etc., makes it necessary, the small streams are very easily stopped out, and the part required made literally dry.

These dams are easily removed after they have served their purpose, or in cases where the fish-way is near the bank a portion may be strengthened and allowed to remain so as to make an eddy, if desirable, at the head of the fish-way. In the construction of the fish-way at Pitt River considerable preparatory labor was necessary. The falls are in a cañon, some eight hundred feet in depth, and it was necessary to cut a trail down to the foot of them on the northerly side, down which all the material, such as lumber for the workmen's shanty, provisions, material for a boat, &c. (for the foot of the falls could be reached only by the side of the river opposite to site of the fish-way), had to be carried on the backs of men, and then it also became necessary to improvise a rope ferry across the river below the falls to get at the work. All of this preparation and the entire completion of the job was done within the sum named in the contract, and, in fact, yielded the contractors a liberal profit; but, you will observe, this was done after the manner of California gold mining. The first contract was made in the summer of 1880, but as the season for work was nearly expended it was not commenced, and the contract was thrown up. We again let it to new parties, residents of the neighborhood, and this last spring and summer it was commenced and completed in about four months. I have never seen the falls of the Potomac, but from what I am informed that river carries, at its falls, a much less body of water than Pitt River, which last, although but a little over 100 feet in width at its falls, is a deep and rapid cañon stream. I fear that I have extended this letter beyond your reasonable patience, but as I consider the great interest

you take in such matters, and looking myself upon this stone fish-way as a marked illustration how economically such work may be constructed, even in the wilderness, and also how many such falls obstruct the passage of fish to extensive spawning-grounds, which could easily and cheaply be removed or remedied by even unskilled labor, I am sure that you will pardon, if not justify, my desire to place in the possession of the chief of our guild all the facts and circumstances of what I am fain to consider as an important and in many respects a remarkable work of the kind. For the purpose of preserving to you the work for reference I will merely recapitulate: Height of falls, 41 feet; length of fish-way, 192 feet; incline, 1 foot in 6 feet; width of rock cut, 10 feet; angle of fish-way, 10°; bulkheads, 4 to 8 feet; space between bulkheads, 5½ feet; openings in bays, 2 feet; depth of same, 4 feet; depth of fish-way, 4 feet.

I will merely add that the rock excavations involved but little blasting, but are mostly the work of the drill, gad, and pick, as their size and form plainly indicate.

Hoping that the matter contained in this may, in part, repay you the reading, I remain,

Yours, most truly,

S. R. THROCKMORTON,
Of California Fish Commission.

Hon. SPENCER F. BAIRD,
U. S. Commissioner of Fisheries,
Smithsonian Institution, Washington, D. C.

NOTES ON A SHIPMENT, BY THE UNITED STATES FISH COMMISSION, OF CALIFORNIA SALMON (ONCORHYNCHUS CHOUICHA) TO TANNER'S CREEK, INDIANA, IN 1876.

By TARLETON H. BEAN.

On the 29th of December, 1876, the writer was sent from Mr. Clark's hatchery at Northville, Mich., to Guilford, Ind., with 15,000 salmon-fry. The fish were distributed in 8 milk cans, and I had one reserve can for water. The day was cold and windy; snow was drifting freely. The temperature of the water in the hatchery was 38° Fahr.

I left Northville at 2.45 p. m. On the way to Toledo, at 4.30 p. m., the temperature of the car above the fish cans was 73° Fahr., while the water in the cans was 37° to 38°. A drifting snow-storm delayed the Flint and Pere Marquette trains; but there was ample time in Toledo, with a margin to spare, for mending a leaky water-pail.

I took a train on the Indianapolis, Cincinnati and Lafayette road at 7.45 a. m., December 30, for Guilford. There was no loss of fish on the way. The highest temperature observed in the cans during the trip was 41° Fahr., the lowest 33°.

Dr. H. C. Vincent entertained me at his home and assisted in the plant-

ing. The salmon were put in at four points on Tanner's Creek, two where the water was shallow, and two with considerable depth of water. We opened holes in the ice for the deep planting. The ice was at least a foot thick; the water temperature was 33°. When the fry were liberated by us they immediately begun to stem the current.

Fine black bass are caught in Tanner's Creek. Numerous springs feed this stream near Guilford.

Dr. Vincent reports the capture of two fish of the 1874 shipment; he will correspond with regard to the progress of the present introduction of salmon.

ACCOUNT OF A SHIPMENT, BY THE UNITED STATES FISH COMMISSION, OF CALIFORNIA SALMON-FRY (ONCORHYNCHUS CHOUICHA) TO SOUTHERN LOUISIANA, WITH A NOTE ON SOME COLLECTIONS MADE AT TICKFAW.

By TARLETON H. BEAN.

The young salmon which were destined for the Louisiana streams were reared from the egg in Mr. F. N. Clark's hatchery at Northville, Mich. On the 19th of December, 1876, Mr. Orrin P. Maxson and the writer were instructed to carry 30,000 of these fry to the Tangipahoa and Notalbany rivers. We took them in fifteen milk cans, and had two reserve cans for water. Fifteen thousand of the salmon were consigned to the Tangipahoa River, at Amite, in Mr. Maxson's care, and the rest to the Notalbany River, near Tickfaw, 10 miles south of Amite and about 50 miles north of New Orleans, on the Saint Louis, New Orleans and Chicago Railroad.

We left Northville at 2.45 p. m. on Tuesday. While in Toledo one of the water cans sprung a leak. We were compelled to draw off the water in pails and distribute some to the fish. We then took the can to a hardware store and had it soldered. As the fish cans had too much water in them, we drew off some and returned it to the water cans.

Our route was by Cincinnati, Hamilton and Dayton Railroad to Cincinnati, thence by Louisville, Cincinnati and Lexington road and Louisville Short Line to Milan, Tenn., and from there by Saint Louis, New Orleans and Chicago road to our objective points.

The only great delay occurred at Milan, where we waited from 4 a. m. Thursday to 1.30 p. m., and here was experienced the only difficulty we had with the fry. The high temperature of the air, as compared with that of Northville, and the standing still, which seems to be particularly injurious to salmon, combined to make them troublesome. Frequent changes of water and aërating by pouring with dippers, however, brought them under control. We found a supply of excellent ice, also, which we used freely in the well water taken here.

After leaving Milan there was no further trouble with the fry beyond the usual care accorded to them. Our stay in the baggage car was attended, however, with some personal discomfort, owing to the pres-

ence of sundry legions of chickens, ducks, and turkeys, on their first visit to the New Orleans Christmas festivities. Conductors and baggage men during the whole route assisted us in every way possible.

We reached our destination on Friday morning—the morning of a very pleasant, warm, and sunshiny day. Birds were abundant. A resident of Tickfaw spoke of his intention to plant pease and beans in a few days. There was abundant evidence of recent rains. The clay subsoil retains widespread accumulations of water over the surface.

A four-ox team drew the cans to Notalbany River, the time occupied in going and returning being about three hours. Messrs. O. M. Kinchen, M. N. Arnold, and W. L. Fairchild accompanied me to see the planting. Notalbany River has pure, cold water (55 Fahr.), running over a bed of clear, white sand and gravel. There are many deep places and numerous little rapids. Big-mouth black bass (*Micropterus pallidus*) abound, much to the jeopardy of the tender salmon. Soon after the fry were put in they started up the stream, and in a few minutes most of them had traveled about 200 yards. The current is quite strong. At one place a rapid caused a short delay, but soon one salmon took the leap and the rest followed.

Mr. Maxson came down from Amite as soon as possible on Friday, after successfully placing his charge in the Tangipahoa. We made some collections of fish in the pools of water left by overflow in the vicinity of Tickfaw. On the following day, December 24, we hauled a Baird seine in the Notalbany, to see what neighbors the little quinnat salmon were to have. We captured a good many of the fry introduced on Friday, and returned them to the stream in fine condition. They were concealed under dead leaves, sticks, and stones, on the bottom.

COLLECTIONS OBTAINED.

In the pools of water at Tickfaw we found *Zygonectes melanops* and a species of some other genus of cyprinodonts, young *Lepomis*, young black bass (*Micropterus pallidus*), a species of *Cambarus*, and a small shrimp. In Notalbany River we seined *Zygonectes notatus*, *Ammocrypta Beanii*, and a representative of another genus of darters, *Lepomis megalotis*, a species of *Noturus*, numerous cyprinoids not yet determined, some mollusks, and the common shrimp. A tree frog (*Hyla* sp.) was also caught near the river. Large numbers of cane rabbits (*Lepus callotis* var.), opossums (*Didelphys virginiana*), and raccoon (*Procyon lotor*) were brought in daily by hunters. Quail were plentiful, but strong in flight and gun-shy.

As to the result of the introduction of California salmon in 1876 nothing is known to me. Mr. W. Alex. Gordon, 30 Carondelet street, New Orleans, has a knowledge of the Tangipahoa, and may be able to give information about the subject.

UNITED STATES NATIONAL MUSEUM,
Washington, November 16, 1881.

[Translation.]

PACHALY'S CAR FOR TRANSPORTING FISH.*

[From "Deutsche Fischeri-Zeitung," No. 43, Stettin, October 25, 1881.]

Some time ago we informed our readers that a joint-stock company had been formed for transporting fresh salt-water fish from Cuxhaven to Berlin, in specially constructed cars. The originator of this plan, and, as it seems, the soul of the enterprise, is the inventor of the car, Mr. Arno Gustav Pachaly, from Mittelgrund, in Bohemia. His invention has been patented in the German Empire, March 20, 1880, and the letter granting the patent says the following regarding it:

"The transporting car is a railroad car, which can be taken off the wheels, the walls of which are double, the spaces between the walls being filled with non-conductors of heat. The top and lateral walls have a threefold covering.

"In the interior of the car, and resting on the double bottom, there is a shallow tank of forged iron with a vaulted roof, on which a stove-pipe is fastened, similar to the stove-pipe frequently seen in the cabins in fishing vessels. This stove-pipe has slanting sides, and can be closed air-tight with a lid. Along the inside walls of the car there are shelves for dead fish. Ice-boxes fastened to the ceiling serve to keep the car cool.

"In order to supply the live fish in the tank with fresh air, the air is from the top of the car led through pipes into the ice-boxes, kept there until it is sufficiently cool, and thence, by means of an air-pump fastened to the lower side of the bottom of the car, forced into the tank. The necessary power is, during the journey, supplied by the motion of the car, the axis of one of its wheels being connected with the disk of the air-pump by means of belts. In order to protect the fish against the danger of suffocation during long stoppages, the disk of the air-pump is so arranged that it can be turned by means of a crank. Each car has, for cases of emergency, an extra air-pump, which is placed in a line with and to the right of the one in general use.

"In order to prevent superfluous air from entering the ice-box, and also with a view of keeping the air above the water in the tank at a slight tension, so as to prevent any violent motion of the water, the stove-pipe of the tank has a lid at the top, composed of four parts, and fastened by screws. To this lid a rubber-tube can be screwed, after the car has been loaded, the other end of the tube being fastened to the ceiling of the car.

"For letting the water off from the tank, it has an opening in the bottom, with a stop-cock, and with an arrangement for fastening a tube to it.

"At one end of the car there is a compartment for the person in charge of the fish. A double door leads from this compartment into the one where the fish are kept; and a person can, therefore, even during the journey, easily pass from one compartment to the other.

* "Der Fishtransportwagen von Pachaly." Translated by HERMAN JACOBSON.

"The invention, about to be patened, is the construction of a car for the transportation of fresh salt-water fish, by employing a tank, by introducing into this tank fresh air, which is absolutely necessary to the well-being of fish, the air having previously been cooled, and the superfluous air having been shut off from the ice-box, with a view of keeping the air in the tank at a slight tension, so as to prevent any violent motion of the water.

"This car is to serve for the wholesale transportation of salt-water fish from the coast to some central point in the interior."

If this invention fulfills all it promises to do—and it is to be supposed that the capitalists who have made it possible to carry out its theory in practice have thoroughly convinced themselves of its usefulness—Mr. Pachaly deserves the gratitude of all fish-dealers. A beginning has been made, and circumstances will finally compel the disobliging railroad companies to be far more accommodating in the matter of transporting fish than they have hitherto been accustomed or willing to be.

MEMORANDUM OF SOME RESULTS OF THE ARTIFICIAL PROPAGATION AND PLANTING OF FISH, DUE MAINLY TO THE EFFORTS OF THE UNITED STATES FISH COMMISSION.

The following chronological sketch shows some of the work accomplished within the last decade by the United States Fish Commission, either directly by its own efforts or indirectly by its co-operation with State commissions. It is, however, very far from complete, and the object of publishing it is only to place on record some scattering items preliminary to a more elaborate and complete article on the subject. The United States National Museum now has many specimens illustrating successful introduction of important species, and these are recorded in this article. The fishes from which returns have been received are as follows:

1. German whitefish (*Coregonus lavaretus*). 2. Maine salmon (*Salmo salar*). 3. Quinnat salmon (*Oncorhynchus chouicha*). 4. Rainbow trout (*Salmo irideus*). 5. Shad (*Alosa sapidissima*). 6. Carp (*Cyprinus carpio*). 7. Catfish (*Amiurus catus*).

GERMAN WHITEFISH (*Coregonus lavaretus* L. *fide* Günther, which equals *C. maræna* Nilsson).

April 28, 1877.—Geo. H. Jerome, superintendent, writes:

"My overseer, Mr. Chase, informs me that but 409 of the 1,700 German whitefish lived to be planted in Michigan waters. The number which survived were very active and healthy, and were placed, on the 14th of April, in Gardner Lake, Otsego County, a small deep lake, where no whitefish had ever been planted, and free from all predaceous fish. The eggs were a little larger than our whitefish eggs. The fish had a larger sac and carried it longer than our whitefish."

2.—MAINE SALMON (*Salmo salar L.*).

1873.

May 9, 1873.—The Germantown Telegraph of this date announces the capture of young salmon in the Delaware River at Easton, Pa.

July 31, 1873.—The Germantown Telegraph of this date announces the fact that young salmon from 2 to 4 inches long are being caught daily in the Delaware in bait nets, and are returned to the river. One party, in one day, caught over fifty.

1874.

May 23, 1874.—Hartford Times, Conn., states that a fine salmon weighing six and a half pounds was caught in a cove, two miles below this city, by Francis Smith. The salmon was bought by a Mr. Cook and divided among three of his customers at 75 cents a pound.

September 18, 1874.—Mr. J. P. Creveling forwarded a salar or Maine salmon 5 inches long (catalogue number, 13068), which was caught in the Susquehanna River at Marietta, Pa.

1877.

November 20, 1877.—Hon. H. J. Reeder, a fish commissioner of the State of Pennsylvania, forwarded an adult female salar salmon which was caught in the Delaware River in November, 1877. (Catalogue number of specimen, 20763.)

1878.

January 14, 1878.—Dr. C. C. Abbot reports the capture, in the Delaware River at Trenton, of a salmon 16 inches long.

April 25, 1878.—E. J. Anderson reports the capture at Salem, N. J., on the Delaware, fifty miles from Philadelphia, of two fresh run salmon weighing 22 and 18 pounds.

May 2, 1878.—Benjamin & West, New York, received a salmon from Saybrook, Conn., weighing 11 pounds.

May 10, 1878.—S. B. Miller, Fulton Market, New York, reports the capture of a salmon in a pound in the sound, near the east end of Long Island, and of six or eight more taken in the Connecticut, two of them eight miles from the mouth of the river.

June —, 1878.—Captain Potter caught between Narragansett Ferry and Hickford a salmon weighing 11 pounds.

July 3, 1878.—Chas. G. Atkins writes:

"We have found two more tags of our salmon, and obtained the record of the fish from which they were taken: No. 768, handled at our pond November 1, 1875, weighing 20 pounds 7 ounces, yielded us 5 pounds 7 ounces of eggs, dismissed weighing 15 pounds; caught at Lincolnville, June 14, 1877, weighing 26 pounds. No. 1010, handled at our pond November 9, 1875, weighing 18 pounds 2 ounces, yielded 4 pounds 10 ounces of eggs, and was dismissed weighing 13½ pounds. Caught again June 13, 1877, at Lincolnville, weighing 30½ pounds."

1881.

September 10, 1881.—Hon. S. G. Worth sent to the United States National Museum two young salar salmon, of the Sebago type, measuring 7½ inches. These were collected at Henry's, North Carolina, on the above date. (Catalogue number of specimens, 29088.)

November 24, 1881.—The same commissioner expressed a specimen of of the land-locked form of salar salmon, measuring 7½ inches in length; this was caught on a hook in Mill Creek, two miles above Henry Station, in McDowell County, North Carolina. The letter of transmittal contains the following information: "3,000 fry were planted in Mill Creek, in the spring of 1880, and 5,000 in the spring of 1881. * * * It may be well to mention the planting of 1,000 California trout in Mill Creek, March, 1880, with the land-locked salmon. These fish must be the original plant of 1880, there being dams below and these the only ones planted above." (Catalogue number of salmon, 29112.)

3. QUINNAT OR CALIFORNIA SALMON (*Oncorhynchus chouicha* [Walb.] Jordan & Gilbert).

1877.

December 14, 1877.—J. B. Thompson forwarded from his hatching ponds at New Hope, Bucks County, Pennsylvania, three quinnat or California salmon, measuring 13 to 14 inches, which had been reared in confinement from eggs hatched in 1874. (Catalogue numbers, 20894, 20895, and 20896.) He also sent two measuring 5½ to 6 inches, which were similarly raised from eggs of 1876. (Catalogue numbers, 20897 and 20898.)

1878.

July 15, 1878.—John S. Robson, New Castle, Ontario, caught a specimen of quinnat salmon weighing 14 pounds, in Lake Ontario.

1879.

June, 1879.—Mr. A. Booth, of Chicago, Ill., sent a quinnat salmon, over 20 inches long, which was caught in Lake Michigan. (Catalogue number, 23203.)

November 3, 1879.—Mr. R. J. Sawyer presented to the National Museum a quinnat salmon, 10 inches long, which was caught at Green Bay, Michigan. (Catalogue number, 23373.)

4. RAINBOW TROUT (*Salmo irideus* Gibbons).

1879.

September 23, 1879.—Mr. Livingston Stone, in a letter from the United States fishery, Shasta, Cal., reporting results of experiments with the California trout (*Salmo irideus*), concludes: "In pure and swift running water the *Salmo irideus* will, in my opinion, easily survive a temperature

of 75° to 80°. My experiments were tried in a tub of water, where, of course, the conditions were unfavorable to the fish."

1881.

May 16, 1881.—A rainbow trout, 14 inches long (catalogue number 27844), bred to this size from the eggs at Northville, Mich., by Mr. Frank N. Clark, was received from the United States carp ponds, Washington, D. C., where Mr. Clark had sent it.

November 24, 1881.—Hon. S. G. Worth, commissioner of agriculture of the State of North Carolina, forwarded, in alcohol, a specimen of rainbow trout, 8 inches in length, which was caught on a hook in the month of August in Mill Creek, a tributary of Catawba River. (Catalogue number, 29113.) The commissioner wrote as follows concerning the fish: "It may be well to mention the planting of 1,000 California trout in Mill Creek, March, 1880, with the land-locked salmon. These fish must be the original plant of 1880, there being dams below and these the only ones planted above."

5. SHAD [*Alosa sapidissima* (Wilson) Storer].

1871.

———, 1871.—The New Bedford Evening Standard, of this date, announces a large increase in the catch of shad in the Connecticut and Hudson Rivers, which is undoubtedly owing to the work of artificial propagation. It further adds:

"Seth Green, in a letter to R. G. Pike, fish commissioner of Connecticut, in answer to his inquiry as to whether there had been an increase in the number of shad caught in the Hudson River, says:

"There has been an increase in the catch in the Hudson River * * * I am not surprised at the increase; it is what I predicted. There is no increase in any river that shad frequent except the Connecticut and Hudson.

"I have just come from the South and find their catch is light everywhere."

1872.

———.—In the report of the Connecticut fish commissioners for 1872, we find that schools of shad in immense numbers were seen in the spring in Long Island Sound, making their way up to the Connecticut River, and on the 23d of May over twenty-eight hundred were taken from a pound near Saybrooke; at another, thirty-five hundred and sixty were taken, and elsewhere they were caught in numbers varying with the locality.

The largest haul previously on record was in 1811, when twenty-two hundred and eighty were taken, though there was a haul said to have been made in 1862 at Haddam Pier of twenty-three hundred.

The abundance of shad in the river in 1871 was still greater than in

the previous year, so much so that in the time of greatest plenty they could hardly be disposed of at three dollars and a half per hundred.

At the present period the increase has been such that numerous fishing stations for a long time abandoned have resumed operations with very satisfactory results. A great increase in the numbers of the shad has also manifested itself in the Hudson and Merrimac Rivers, and with a reasonable continuance of effort there is every reason to expect that the pristine abundance of the fish will be restored, and possibly increased, if young shad are hatched out in sufficient numbers.

- ——, 1872.—The Germantown Telegraph says:

"In the year 1867 there were two million young shad hatched in the Connecteut River, and in 1869 four millions. The official report of the Connecticut and Massachusetts commission for 1871 stated that there were 60 per cent. more shad in the river that year than in 1802 and 1870, and 200 per cent. more than in 1862 alone. There had been a gradual decrease until 1870."

1873.

May 9, 1873.—A letter received by Seth Green from Frank B. Leach, editor of Vallejo Chronicle, California, says:

"The first shad ever caught in California waters was taken Monday, by Baltimore Harry, and is now on exhibition at stall 79 and 80, California Market, San Francisco. The Piscicultural Society had offered a standing reward of $50 for the first of these fish caught in the waters of this coast. There is no doubt about this fish being a shad. It was caught in the net of Alex Boyd & Co., at the junction of the Casquinez and Vallejo Straits, opposite the navy-yard magazine. The stranger was about 16 or 17 inches in length.

"On April 30 announcement was made that a shad measuring 13 inches in length was caught in the nets of the same firm, and brought to the Chronicle Office. The Chronicle states that A. Boyd and Company have been catching the same kind of fish for some weeks past. Being unacquainted with the species of fish, they attached no importance to it, and have been eating them as fast as caught. Mr. Boyd says he noticed they were very good eating. They have caught some thirteen of them."—(From Rochester Union and Daily Advertiser.)

May 20, 1873.—Mr. Livingston Stone writes that a true shad was caught at San Francisco, in the mouth of the Sacramento River, on the 28th of April preceding.

May 24, 1873.—An item in the Rochester Union and Advertiser of this date states that "a Mr. Parkhurst, of Stapleton, N. Y., near the mouth of the Genesee River, caught a shad in his seine. The same item says, that last year persons caught a number of young shad in scoop-nets, and the event was duly noticed."

September 10, 1873.—The Rochester Union and Daily Advertiser of this date announces that a shad 15½ inches long, well developed, was

taken from the Alleghany River at Tidioute, Pa., sixty miles below Sulana, where shad were put in by Wm. Clift, in 1872, under direction of the United States Fish Commission.

1874.

April 8, 1874.—The Germantown Telegraph of this date, quoting from the New York Sun, says:

"During the shad season on the Hudson, lasting from the 1st of April till the middle of May, one million fish (shad) are usually taken, worth about $300,000.

"Fishing is begun along Sandy Hook; and from there to Stapleton, Staten Island, drift-nets are used.

"From Stapleton to the Highlands stake-nets are employed. Poles are set at regular intervals across the river, leaving room for vessels to pass. To these poles gill-nets are fastened, and the fishes passing up the river are caught. Above the Highlands drift-nets are used. Very few shad are caught above Hudson and Kinderhook, although a few run to Troy. The nets have 5⅝-inch meshes. Higher up the river smaller meshes are used. The nets are lifted every high water, and thus the fish are caught going up the river with the tides.

"Three years ago in the Hudson the fish were so run down that many fishermen gave up fishing. The fishing has greatly improved since the expenditures in artificial breeding."

May 16, 1874.—The Saint Paul Pioneer, of Minn., of this date, says:

Captain Johns has in his possession the first shad supposed to be of those placed in the Mississippi two or three years ago. It weighs 5 pounds 9 ounces, and is 18 inches long. Mr. Williams states that thousands of these fish are dancing around in the waters of the lake" (probably *Pomolobus mediocris* according to Milner).

May 18, 1874.—Providence Press, R. I., says: "The shad catch is the best this season that it has been for fifteen years. The results of shad culture are beginning to be seen."

May 25, 1873 or 1874.—Mr. Benjamin Shurtleff, Shasta, Cal., writes, May 20, to Hon. B. B. Redding, State fish commissioner, that on the 14th instant Judge Hopping, Wm. Jackson, and Jos. Brown caught a fish in a net in the Sacramento River, at Jackson's Ferry, that was doubtless a shad. The fish was 12 inches in length, and weighed about a pound. These gentlemen seemed to have more interest in trying the flavor of their first shad from the Sacramento than of making the identity of the fish certain or of obtaining the $50 reward which was offered by the State for the first shad taken. Judge Hopping is a native of Keyport, N. J., and familiar with the shad of the Raritan Bay and River, while Jos. Brown is a native of Fall River, Mass., and claims to know the shad thoroughly.—(Sacramento Daily Record.)

May 26, 1874.—The Hartford Post, Conn., says:

"The fact is, however, that shad are now more abundant and the

catch is larger than it has been for some time past. The fishermen think the reason is all attributable to the method of propagation now in vogue."

——, 1874.—The Appleton Post, Wis., announces that shad 3 or 4 inches long have been seen in Fox River, near Appleton, in large quantities.

December 12, 1874.—Oswego Times, N. Y., of this date states that on the day previous a gentleman fishing with a fly from the pier of that harbor captured a shad measuring 9 inches and weighing one-quarter of a pound.

December 18, 1874.—The Albany Advertiser of this date says: The efforts to stock interior lakes and rivers with shad have proved remarkably successful. Large numbers have been taken at Port Dalhousie, and one was recently caught at Cape Vincent weighing 4¾ pounds.

The fact that shad can be successfully introduced into Lake Ontario has been fully established.

1875.

April 3, 1875.—Albany Argus, N. Y., announces larger hauls (of shad) in the Hudson than in any year for a long time, the total catch being 1,000,000. This led to a sharp decline in the price of shad all along the river.

Unknown, 1875.—The productiveness of the different shores on the Delaware this season is a matter of daily comment.

At the Gloucester shore, on Monday, upwards of 2,200 shad were taken at one tide. A few days ago the fishery at Carpenter's Point, in Salem? County, caught 2,500 shad in one haul.

Gill-nets have multiplied threefold the present season, and all have been successful. The shad run larger and have been better flavored than for many years past.

1877.

May, 1877.—Pack Thomas, esq., sent from Louisville, Ky., an adult shad, the first return from the introduction into the Ohio River. (Museum catalogue number, 19612.)

December 1, 1877.—Received a shad from Sacramento River, caught two years ago. It is apparently a spent adult male. (Museum catalogue number, 20845; sent by William S. Bassett, Sacramento.)

March 20, 1878.—T. B. Doron, Montgomery, Ala., sends a four-pound shad, caught at Wetumpka, on Coosa River.

April 18, 1878.—Dr. R. J. Hampton, Rome, Ga., reports that shad planted by the United States Fish Commission some years ago are now caught in large numbers.

(*July* 11, 1876.—90,000 placed in Alabama River, at Montgomery.)

May —, 1878.—Mr. Griffiths forwarded to National Museum two adult female shad (catalogue numbers, 21345 and 21346) from the Ohio River, at Louisville, Ky.

May 3, 1878.—George Spangler, Madison, Ind., announces the capture of about a dozen shad this season; sold for a high price. Two were caught last year 20 miles below Madison.

May 21, 1878.—George F. Akers, Nashville, Tenn., says: "During present month quite a number of shad were taken near Nashville and sold in market."

May, 1874.—Col. Marshall McDonald, fish commissioner of Virginia (report of 1878), speaks of marked increase of shad in the Rappahannock River, and says it is the general belief of the people that this is due to the planting of young fish by the United States Fish Commission in 1875.

April 15, 1879.—Rev. T. M. Thorpe sent to the National Museum an adult female shad, which was caught near Hot Springs, Ark., in the Washita River.

6. CARP (*Cyprinus carpio*, Linn.).

1880.

December 10, 1880.—Mr. J. B. Rogers, of Duval, Travis County, Texas, sent to the United States National Museum, through one of the messengers of the United States Fish Commission, Mr. J. F. Ellis, a fresh carp reared from a lot introduced by the Commission eleven months previous to the above date. In this short time, under the favorable conditions found in its new home, this carp (from about 4 inches) reached the astonishing length of 20½ inches, and weighed 4 pounds and 11 ounces. The fish was brought by Mr. Ellis in a fresh state; a cast of it (No. 963) is preserved, and the specimen may now be seen in the Museum. (Catalogue number, 26629.)

7. CAT-FISH (*Amiurus catus* [L.] Gill).

———, 1877.—Received a cat-fish from Sacramento River, caught two years ago. (Museum catalogue number, 20846, entered December 1, 1877.) It came with a shad from Sacramento River.

EXPERIMENTS IN THE TRANSPORTATION OF THE GERMAN CARP IN A LIMITED SUPPLY OF WATER.

By MARSHALL McDONALD.

The extreme hardihood of the German carp, and the great tenacity of life exhibited under adverse circumstances, led to the institution of experiments to determine whether we could not with safety greatly decrease the amount of water employed in their transportation and thus reduce the cost of their distribution.

A common covered tin bucket, capacity 6 quarts, was procured, and several holes made in the cover to allow free access of air. The bucket

was then filled nearly half full of water and in it were placed 22 carp, from 2 to 3 inches long. This was at 4 p. m. on the 15th of November; they remained in this water until 9 a. m., 16th. The water was then poured entirely off, and the bucket filled about half full of fresh water. The fish remained without further change of water or attention until 4 p. m., when an entire change was made, and the bucket of fish shipped by express to Eugene Blackford, Fulton Market. A card of instructions attached was as follows:

"Professor Baird wishes to ascertain if these carp will go to New York and return to Washington without change of water, or other attention than to keep as cool as practicable. Will Mr. Blackford examine the fish immediately upon arrival and verify their condition, and return them by first express to Washington, D. C. Don't make any change of water before reshipping, unless the condition of the fish seems to be bad."

The fish arrived safely in New York at 9 a. m. on the 17th. Mr. Blackford telegraphed:

"Fish arrived in good order. Kettle one-quarter full of water; will return by evening train."

At the same time he wrote:

"Kettle of carp arrived at 9 a. m. Fish all alive and looking well. Kettle only one-quarter full of water; either leaked out or slopped over from careless handling. I have sent them back on the Express that leaves to-night. I have not added, or changed the water; in fact, done nothing but attach a tag to the kettle and send it back. I have no doubt they will reach you all right in the morning."

The fish returned to the Smithsonian, at 11 a. m. on the 18th, all looking strong and well, and but little more than a pint of water in the bucket. In this they remained, without change, until 9 a. m. the 20th, when they were all alive but apparently weak. A change to fresh water immediately revived them, and they were soon as strong and vigorous as ever.

These fish had now been in less than 4 pounds of water for 89 hours, and had gone to New York and returned to Washington, subject to the rough handling which express packages usually encounter, no precautions having been taken to secure unusual care or attention in transmission.

The result of the experiment was so encouraging that it was determined to try a shipment of 750 fish in buckets. The details of this experiment were intrusted to W. F. Page, a messenger of intelligence, judgment, and long experience. The result of the experiment he thus reports:

"The carp were put up in twelve 6-quart pails, 50 carp to each pail, and the pails packed in a crate measuring $20'' \times 30'' \times 18''$. I also had an extra 4-quart pail, which I will here state received the same attention (that is, no attention) as the 6-quart pails and gave the same re-

sult. The fish were put up about 4 p. m. on the 25th instant, but at 4 a. m. the 26th, the night having been unusually cold, many fish were either dead or torpid from freezing; these were emptied out and replaced with fresh fish before starting for the 6.30 a. m. train. In the dark and hurry, as I afterwards discovered, quite a number of fish larger than are usually sent out in cylinder cans had been given me. Reached Richmond at 11.30 a. m., and laid over until 11.25 p. m. Had the fish carted up to the Saint James Hotel, for the double purpose of placing the experiment under all the conditions likely to arise on an ordinary trip, and that they might be seen.

"Leaving Richmond at 11.25 on the 26th, reached Danville at 7.30 a. m. on 27th. At Danville had the last bucket weighed at Coon's drug store. This bucket was an especial experiment, made at the instance of Professor Baird. It had from the start just as little water as would cover the fish; in fact, several had their backs above water. The weight of bucket, water, and fish was 4 pounds 7 ounces (65 ounces); of the bucket and water, 2 pounds 13 ounces (45 ounces), leaving the weight of fish 20 ounces. The weight of water by measure was 20 ounces, from which I conclude that one pint of water will carry one pound of fish (carp) without attention for at least 30 hours. Whether this relation will hold true with larger fish remains to be determined.

"In conclusion I would state that the water was so low in the buckets as to occasion no slop in the car. In fact, on the route from Richmond to Danville, the crate was at the top of a high pile of baggage, and the baggage was dry and in good order the following morning."

It seems hardly credible that a number of carp could live for any length of time in hardly more than their own weight of water. Experiment has, however, demonstrated the fact, and the explanation is probably this:

What the fish require is not water but air, water being the necessary medium through which they appropriate air. The air in a small quantity of water would be very quickly exhausted, and if there was no adequate provision for renewal of supply the fish would quickly die.

In the case of the fish in the small pails the free air surface of the water is very large in proportion to volume. It is kept in continual agitation by the jostling of the cars, or when at rest, by the movements of the fish. Consequently, although the oxygen in the water is rapidly and continuously exhausted, it is, also, rapidly and continuously renewed, and the fish remain in good healthy condition. It follows from these experiments that 25 or 50 carp in a half gallon of water in a shallow pail are really under better conditions for healthy existence than the same number of fish in the ordinary 8-gallon shipping can. The limits of distance and temperature within which this method of shipment may be resorted to can only be settled by further experiments.

WASHINGTON, *November* 29, 1881.

Since the conclusion of the experiments detailed above, the feasibility of shipping carp in crates and pails has been pretty thoroughly tested in the operations of the United States Fish Commission, with the following results: Single shipments in pails have been made from Washington into New York and Pennsylvania, and to Ohio, North Carolina, and Tennessee. Some losses have been reported, but comparatively few, the usual report being that the fish are received in good condition. In the case of a shipment to Reedville, N. C., the fish were eight days *en route* and were received in good condition.

Crates containing 16 buckets and 320 fish have been sent by express from Washington to Chattanooga and Grand Junction, Tenn., and Jackson and Meridian, Miss., and distributed from these points by Express to parties within a radius of 100 or 150 miles, without more than the casualties incident to transportation by the methods heretofore pursued. In conclusion, we may safely say that where the point of destination is not distant from the point of departure more than 24 hours, 25 or 30 carp may be safely shipped in an ordinary covered 4-quart tin pail.

Where the temperature is kept below 60° Fah., and freezing is avoided, it is probable that the fish may be 6 or 7 days *en route* without loss or injury. Some modification of the pail to prevent loss of water by slopping over is desirable, and it is to be presumed that the ingenuity of our fish-culturists will quickly supply the want.

WASHINGTON, *December* 25, 1881.

INTRODUCTION OF THE ALAND OR ORFE INTO ENGLAND.

[From The Field, March 28, 1875, 299.]

One of the few fresh-water fishes which have a wide range over the continent of Europe, but are not found in the British Islands, is the "aland" or "nerfling" of the Germans, the "id" of the Swedes, named *Leuciscus idus* or *melanotus* by ichthyologists. It may be shortly characterized as *a chub with smaller scales;* for whilst the chub has, at the most, forty-six scales along the lateral line, the aland has never less than fifty-six, and sometimes as many as sixty; in its habits also it much resembles the chub, but prefers large to small streams, and inhabits lakes as well as rivers. Its usual size is about twelve inches, but it is known to have attained to a length of eighteen and twenty inches, and a weight of six pounds.

Normally this fish has the same coloration as the chub, being somewhat darker on the back; and, consequently, the two species have been constantly confounded with each other, and described under the same names, even to within a very recent period. However, for more than two centuries a singular variety, with bright colors like those of a gold-fish, has been cultivated in lakes and ponds of Bavaria, especially near

the town of Dinkelsbühl. It is called "orfe" by the country people, and Linnæus and most of the following writers mention it under the name of *Cyprinus orfus*. Being one of the ichthyological curiosities of the country, it did not escape the notice of the observant Willughby, who says, in his "Historia Piscium" (Oxon. fol. 1686), p. 253: "At Augsburg we saw a most beautiful fish, which they call the 'root oerve' (red orfe), from its vermilion color, like that of a pippin apple, with which the whole body is covered, except the lower side, which is white." He gives a characteristic figure of the fish (tab. L, 9), and expresses a doubt whether the color is natural or rather the product of some artificial manipulation.

The orfe, however, is as natural and as permanent a variety as the goldfish, which latter, in its original wild state, in the fresh waters of China, has no bright golden colors, being scarcely distinguishable from the Prussian carp in this respect; in fact, the bright coloration of these fishes is nothing more nor less than the sign of incipient albinism, and has been observed also in other fishes, more especially in the tench (in which it is perpetuated by culture), and more rarely in the cod-fish, haddock, common sole, turbot, and eel. Perfect albinism, or total absence of a coloring pigment, appears to be very rare in fishes; indeed, we know of only one species in which white individuals sometimes occur, viz, the goldfish. Analogous cases of a similar modification of the pigment are the common yellow varieties of the canary-bird, light-colored moles and mice, and many other mammalian albinos whose white hairs are tipped with yellow, producing a distinctly yellow tinge over the whole fur.

We introduce this fish to the notice of the readers of The Field because we have been informed that Lord Arthur Russell has succeeded in introducing it into England. He had already made an attempt last year to obtain living specimens from Germany, but only two examples survived the journey. Taking advantage of the experience then obtained, and favored by the unusually low temperature of the second week of the present month, he had the gratification of receiving 112 specimens without a single death during the journey. They were dispatched from Wiesbaden, under the care of a man who arrived in London after a journey of only 25 hours. Next day the fish were safely deposited in a lake at Woburn Abbey.

We have no doubt that Lord Arthur Russell's experiment will prove to be a permanent success. We have always held that the chances of success in introducing a foreign animal are particularly great, if such an animal has been kept in a more or less domesticated condition in its native country. This is the case with the orfe. As an ornamental fish it is far preferable to the goldfish, on account of its rapid reproduction, larger size, and livelier habits. It takes the bait, and on the continent it is eaten. In very small tanks or muddy ponds the goldfish will always hold its ground, but for larger ponds and lakes with clear water we know of no more ornamental fish than the orfe.

In conclusion, we may mention that Yarrell introduced the aland into his "History of British Fishes," in consequence of having heard that a single specimen had been obtained at the mouth of the Nith. He does not appear, however, to have seen the specimen, and the figure and description are borrowed from a work on Scandinavian fishes.

REPORT ON A TRIP IN GERMANY TO SECURE CARP FOR THE UNITED STATES FISH COMMISSION.

By Dr. O. FINSCH.

BREMEN, *August* 20, 1875.

Professor BAIRD:

Having returned on the 18th from our trip to obtain fishes for you, I hasten to give you a report.

As I wrote you in my last letter of August 10 I had decided to help in the matter as much as I could, and in consequence offered my services to arrange matters for Mr. Welsher. It was clear that a mere interpreter was not sufficient, and that the subject needed a man acquainted with the matter, and of ability to represent your interest. So I decided to assist him myself, although my own work was in many respects pressing.

I told you in my last letter that there would be great difficulty in obtaining carp, as it is not the proper season, and I am glad to learn that Mr. Hessel confirmed the statement.

I remark, though perhaps I have referred to it before, that our carp are cultivated in ponds, and are not fished for earlier than about the last of October or November. These ponds are partially emptied of the water, and the carp gather in the deep places, where they are caught with hand-nets. As the carp spawn in July, the ponds are full of young fishes, or eggs in the process of hatching, and this is the reason why the fish cultivators dislike to draw off the water, as it is apt to destroy the newly hatched fish. Besides it does not answer to empty the water during the hot weather, as the heat would then be very destructive to the fishes of all sizes.*

As I wrote you in my letter, I had endeavored to ascertain where there were smaller ponds that I might obtain a small number of each of the chief varieties, the scaled carp (*Cyprinus carpio*), the mirror carp (*C. rex-cyprinorum*), and the naked carp (*C. nudus*). Our principal difficulty was that but seldom were two of the kinds cultivated in any one place, and we were obliged to go to different places. Now the naked carp is chiefly raised in middle North Germany, the mirror carp in South Germany, and the scaled (genuine) carp in North Germany, (Mecklenberg, Holstein, &c.), in Bohemia and Silesia; the latter being

*For this reason at this time of year the fish-cultivators will not sell carp even if offered high prices.

near my birthplace, I have the addresses of many carp raisers in this vicinity.

My chief object was to get the carp from a place as near as possible to Bremen, in order that they might not be transported too long a distance; as during the hot weather we had at this time it would prove fatal to the fish. With this end in view, I wrote a great number of letters seeking the desired information. Some were unanswered, and nearly all regretted not being able to procure us carp at this season.

I wrote (July 30 and August 9) to Mr. Lewin Fischhof, near Cassel, who has a large establishment for mirror carp with ponds of more than 600 morgen (acres) in area. Received answer the 6th August; impossible to get carp now; not before October; then in sufficient numbers. Rare to get fine carp.

Wrote to the Fishery Inspector Stengel, of Giersdorf, in Silesia, a place where I know there are fine carp. Got answer in due time; he would procure me a supply of scaled carp, but as Messrs. Welsher and Green took particular interest in mirror carp and naked carp, I could not accept his kind offer; besides, it was too far away.

Wrote to W. Link, in Wittengen, province of Hanover, one of the nearest places to Bremen, but they could not furnish us now.

Wrote to Fishermaster Schieber, at Hameln, but he did not know of any carp.

Wrote to fishery establishment at Lubbinchen, near Güben, province of Brandenburg; received answer they would furnish us all three kinds, but not before November.

N. B.—Hessel obtained at Lubbinchen, goldtench (*Cyprinus tinca*, var. *auratus*).

Wrote to Mr. Traugolt Mende, at Drobrilugk, province of Brandenburg. He could not give carp now; has fine wrasse.

Wrote to the fisheries of the Prinz Schwarzenburg, in Wittengen, Bohemia, who sells about 716,700 pounds a year; received no reply.

Wrote to the fisheries of the Prince of Schaumburg-Lippe, where the finest naked carp are raised, which I know very well; received no reply before we started.

Wrote to Oberamtmann Nehrkorn in Biddahausen, near Brunswick; received no reply.

Wrote to the Nassauische Fischerei Actican Gesellschaft, in Wiesbaden; replied we could have common carp, mirror carp, and goldorfe (*Idus melanotus auratus*).

When the letter of Mr. Hessel arrived I had already done this, but as he gave me the address of Nürnberg and Gunzenhausen for mirror carp, I wrote there also; but received no answer. Mr. Hessel advised me not to go to Hungary, where he took his carp, as they would starve during the hot weather, and he even thought it best to take carp at Holstein or Mecklenburg; but, unfortunately, we did not know to whom to apply, and I thought it useless to go there.

To neglect nothing, I wrote to Messrs. Kupnert & Sons, in Hamburg, the address given by Mr. Hessel, to obtain more information about the places where we could get carp. The reply was it would be useless to go there, as we could get none at this season, and not before November, and, besides this, none but the genuine scaled carp are raised in this part of Germany.

After considering all these circumstances, I thought it best to go to Wiesbaden, where we were sure to get three different kinds, common carp, mirror carp, and goldorfe. To go to Hungary was too far, and my time would scarcely have allowed it, and at all the other places we would have obtained but a single kind.

You had desired to get carp and its varieties, and as I had hoped to get naked carp at Brickeburg, I thought it possible to get all three kinds, and goldorfe as well. Of the latter you did not write, but Mr. Hessel seems to have brought some over, although in your letter you speak of only goldtench (*Cyprinus tinca-aurata*).

We started on the 14th (Sunday) to Brickeburg, which lies nearly on the route to Wiesbach, but all my endeavors to obtain a supply of naked carp were fruitless.

In the pond near the principal castle we saw a great many naked carp, among them fellows of about 30 pounds weight, but the Hofmarshall and the Oberforestmaster, the only persons who would have power to let us fish with a hook, were absent, and no one could allow us this privilege.

In the afternoon we drove to Heesen, a village in the neighborhood of Brickeburg, where, also, my efforts were fruitless. Mr. Bodeman, the superintendent of these fisheries, tried (after we went away) to catch a supply by hook and net, but without success; and you may be sure he did what he could.

In the evening we went, by the way of Hanover and Frankfort, to Wiesbaden, where we arrived at 11 o'clock a. m. the 15th. I went immediately to Mr. Kirsch, the director of the Nassauische fishery establishment. We went on Monday with him to Hochst, near Frankfort, where there is a second establishment. To my great regret, there were fewer mirror carp than he thought, and, in consequence of the extremely hot weather, he dared not run the water off, and, as there were small islands in the pond, the fish escaped the net. We could only get common scaled carp and goldorfe.

The latter, I told you, is not a genuine species, but a red variety of the aland or nerfling (*Idus melanotus*), just as the goldtench is of the common tench. Although Mr. Kirsch, who has hatched goldorfe for eight years, is convinced that it is a valid species, scientific people do not believe this; neither do they consider it as delicious a fish as the genuine species.

The aland is not valued very highly, but, on the other hand, Mr. Kirsch has kept this variety for eight years, and they are very dear, being very rare.

You may reckon at all events the goldorfe to be a rare fish, and if Mr. Hessel has brought them over, you possess one of the rarest of our fishes. There may possibly be found considerable difficulty in hatching them. You should keep them in small ponds apart from all rapacious fishes.

In accordance with with Mr. Welsher's agreements we procured—

	Marks.
39 small orfe (yearlings), at 1.70 marks	66.30
5 middle size orfe (2 year olds), at 3 marks	15.00
6 large orfe (4 and 5 year olds), at 6 marks	36.00
50 small carp (common scaled), at 50 pfennigs	25.00
	142.30

We started with them in three tin cans (borrowed from the establishment at Wiesbaden), on the morning of the 17th, with the express steamer from Bieberich to Cologne, where we arrived at 5.30 p. m.

It was the hottest day we had had during the summer. The thermometer (Reaumur) indicated 27° in the shade (95° F.). It is needless to enumerate the difficulties we encountered in the care of the fish.

Mr. Welsher supplied them at short intervals with fresh water from the Rhine, and with great trouble I obtained a piece of ice, otherwise we should have lost all the fishes within the first hour. Many of them turned on their backs, but fresh water and ice revived them. On reaching Cologne, we had lost only two of the carp.

At Cologne I had some trouble to get the fish into the baggage-car of the express train, as this is not allowable in this country; but I spoke to the superintendent, who was kind enough to allow it. I ordered by telegraph fresh water to be ready at the few places the train stopped longer than three minutes, and so, with great trouble and much fatigue, we arrived at 4 o'clock a. m. on the 18th, the fish being all in good condition, as the night had been cool.

Here, in Bremen, we have deposited them in a fine marble water reservoir, where they continually get fresh cold water, so that they are in first-rate condition. Mr. Welsher will go on Wednesday (25th), as the Saturday steamer is so crowded there is no place for him. I have no doubt he will bring over the fishes safely, being provided with fresh water and ice.

I was disappointed to find that the carp we got at Wiesbaden were not a fine and good quality, as they are indeed hybrids between the carps (*Cyprinus carpio*) and the karausche (*Cyprinus carassius*) or brachsen (*C. brama*), a form which is very common and of little value, having too many bones and too little flesh; but when we were at Wiesbaden we did not see these smaller ones only as they were swimming through the water, and I could not exactly distinguish what kind they were. It may be that Mr. Kirsch did believe his carp were fine ones, as genuine carp are indeed rare, but, this hybrid one is common. I regret that the carp are not good, for which I will be wholly responsible; but,

as I have said before, I did not see the carp before they came to Bremen, as while we were at the establishment they could not catch a single one, so we trusted Director Kirsch, who said they were first-rate.

Besides these two kinds of fishes, Mr. Welsher will bring with him fifty hybrids between *Cyprinus carpio* (good rape) and *C. auratus* which we will get, as I told you in my last letter, from Mr. Wagner, at Oldenburg.

This hybrid is a good one, grows to 4 to 7 pounds, has a fine flavor, and will be a prolific species, as it has been crossed with fine carp.

This is all I could do to procure you fish now, but I will be able in November to send you fine first-rate carp of all varieties, as they can be carried then without a man to especially attend them.

* * * * * * *

Yours, very truly,

O. FINSCH.

I received your letter of August 20, including Mr. Hessel's; but letters reach me here even if my name is not correctly written, as I am well known. So it was not necessary to send the letter again, though it was cautious.

I received after awhile some information from Director Kirsch, at Wiesbaden, in regard to the goldorfe. They spawn in June and July, depositing their eggs on roots and small twigs of trees, from which material a wall is built across the pond, which measures, perhaps, 25 to 30 long and 15 to 20 broad. As soon as the eggs are deposited the year-old fishes must be removed, because they eat up the eggs themselves; this is an important fact.

In regard to the transportation of carp, I think, after my experience, they can be carried even in hot weather (as we were out the hottest day of the whole year) if one has sufficient means to arrange things before, as ice, fresh water, &c. The ride on the railway did not injure the fish as the water had motion, but should be made only at night when it is cool (our nights are cooler than in America); during the day they ought to be kept quiet to refresh them. The worst part of it was not getting the carp, for, I think, we could have brought them all in safety.

If you should want a supply of fine carp, I could procure you all three kinds, but I ought to have complete instructions and power long enough beforehand to make all preparation; then I would go myself to places in Bohemia and Silesia when fishing commences in order to choose, myself, every specimen, so that you would get true carp. Naked and mirror carp are, as you know, only cultivated varieties and not genuine species. Some pisciculturists prefer these carp as being more valuable, but others consider them of less value, as they grow slowly and are not good for propagation.

The tench is a fish which I recommend you highly, being hardy and

thus easy to transport. In case you want carp again write me early. I think the following way would be best and cheapest: I would go after the carp to the ponds where they are caught, taking with me an assistant to carry the fish to Bremen, and I would settle with the Lloyd Company and with the captain of the steamer—some of whom I know personally—offer him a reward in order to have one of the crew look after the fishes several times a day. As the weather is cold in November, the fishes will require no other attention than fresh water occasionally, and this can as well be given by a common sailor. When the steamer arrives you could send an experienced man to convey them to their place of destination. In this way the expense would be much diminished, and I shall be able to have the necessary funds here. You will trust me to do all I can, just as I did this time. But now circumstances were against me, and I regret that I was not better able to fulfill your expectations. But Mr. Welsher will tell you that I neglected nothing. As I have told you before, the carp we obtained are not true carp, but a hybrid form; it will be of less importance if Mr. Welsher does lose them. They were injured in catching, not being handled carefully, some of them showing spots destitute of scales, and these specimens will surely starve. Such fish, when they lose slime and scales, are sure candidates for death.

In regard to the shad, Mr. Welsher will tell you. After his statement, I am sure the eggs were spoiled before they reached the steamer, so that it would not be correct to say they died at sea. As the hatching apparatus of Mr. Green is no doubt perfect, I see no reason why the fishes could not be hatched on the route. It has never been tried before to carry shad eggs by railway, and experience has shown that this spoils the eggs, as they are too delicate to endure the shocks. But I believe if they were taken down the Hudson in a small steamer they would reach the Lloyd steamer in safety, and, with Messrs. Welsher and Green, I believe they would have been hatched successfully. So if there is courage enough to try them the third time, it will be successful. I know you have much perseverance, and I am in hopes that next year you will make a new experiment. In this case it would be best not to take men who have already crossed the ocean. But I will say no more on this subject at present.

I hope this letter will give you all the information you wish, and so I will close. Accept my best compliments and the expression of my kindest regards.

Ever yours, very truly,

O. FINSCH.

March 24, 1882.

THE WINTER HADDOCK FISHERY OF NEW ENGLAND.

By G. BROWN GOODE and CAPT. J. W. COLLINS.

The winter fishery for the capture of the haddock, *Melanogrammus æglefinus*, is carried on chiefly from the ports of Gloucester and Portland, though participated in to some extent by vessels from Portsmouth, Swampscott, and Boston. Although haddock are caught in large quantities, from spring to fall, by numerous vessels and boats employed in the inshore fisheries between Portland and Philadelphia, the winter haddock fishery is peculiar in its methods. It is of comparatively recent origin, dating back about thirty years. We are told that in 1850 immense quantities of haddock were caught on the trawls in Massachusetts Bay, and that a petition was prepared by the Swampscott fishermen asking for a law which should prohibit trawl-fishing, on the ground that this method would soon exterminate the haddock. It is impossible to trace with any degree of certainty the steps in the historyof this fishery, since it is pursued for a few months in the year only, by vessels otherwise occupied a large portion of the time. Since the fish have always been disposed of in a fresh condition, they have been less carefully recorded.

FISHING GROUNDS.

The winter haddock fishery is prosecuted, from October to April, on all of the inshore ledges and the nearest of the off-shore banks south of Sable Island bank and north of Sandy Hook. The principal haddock fisheries are, however, located north of Cape Cod. The depth at which the fish are taken varies with the locality, but is within the limits of 25 and 90 fathoms; usually in water deeper than 30 fathoms.

In the fall, when fishing first begins, the vessels set their trawls along the coast from Nantucket Shoals to Grand Menan, in 30 to 90 fathoms of water. On the outside of Cape Cod the fishing is within 5 to 15 miles of the shore; in Massachusetts Bay, principally on the outer slope of Middle Bank and the southern slope of the shoal ground that lies to the eastward of Cape Ann, usually called "the Southeast," the eastern part of the shoal water on Jeffries Ledge, and along the coast of Maine within 30 miles of the shore, especially about Monhegan Fall, South-southwest and Western Ground. Fishing in this region continues until midwinter, and is kept up by a smaller class of vessels, such as those hailing from Portland, throughout the whole season. In the latter part of January and in February the larger vessels, comprising the major portion of the Gloucester fleet, strike farther out to sea, fishing upon George's Bank, usually in 25 to 40 fathoms, near the localities frequented by the winter cod-fishermen, and also on the western part of the bank. They also fish on Brown's Bank, in water about the same depth, and on

Le Have and about Cape Sable. The fishing on Le Have Bank for haddock was first attempted in the winter of 1880–'81.* This fishery has been attended with the greatest success. Fishing continues on these outer banks until the end of the season, when it is time for the vessels to engage in other fisheries.

THE FISHERMEN.

The fishermen who take part in this fishery are usually picked men from the Gloucester fleet. A large portion of them are engaged in the mackerel fishery in the summer.

This fishery requires as much skill, pluck, and endurance as the halibut fishery, and men are selected in both of these fisheries on account of similar qualifications. Not unfrequently the same crew will remain with the vessel in the summer when she is in the mackerel fishery, and in winter when she is in the haddock fishery. There is so much competition among those who desire to ship with a good skipper that very often his entire crew list is made out five or six months in advance.

THE VESSELS.

The vessels composing the winter haddock fleet are chiefly the staunchest and swiftest of those which in summer engage in the mackerel and cod fisheries. The Portland fleet is made up of a smaller class of vessels, averaging from 35 to 40 tons; these in summer are engaged in the mackerel or shore fisheries. The few Swampscott and Boston vessels which take part in the winter haddock fishery are marketmen and mackerelmen in the summer.

The rigging of the haddock catchers is precisely similar to that of the halibut catchers, with the exception that very few of them carry gaff-topsails and riding-sails.† Their outfit of nautical instruments and charts is, as might be expected, less complete.

Since the haddock vessels are rarely, if ever, anchored on the fishing grounds, their arrangement of cables and anchors is very different from that in use in the halibut and George's fleets. They usually have a chain cable on their starboard side, and upon the port side a cable similar to that used by the George's and halibut vessels, from 150 to 225 fathoms in length, which is stowed in the fore hold. One end of this cable is bent to the anchor and the other passes down through a hole in the fore hatch and is coiled below in the forehold. The anchors are like those used on "Georgesmen."

The deck is arranged in a manner different from any that has yet been described. There is usually a single gurry-pen forward of the

*Capt. S. J. Martin, of Gloucester, writes, under date of May 10, 1881, as follows: "The first vessel that went to Le Have Bank for haddock was the schooner Martha C., of this port. She made her first trip there last winter."

†Since 1879 many of the largest vessels of the Gloucester fleet have been employed in haddock fishing; these generally carry riding-sails, and many have gaff-topsails.

house, and the space between the sides of the gurry-pen and the house, and the rail on either side, is so arranged that it can be divided into pens for the reception of the fish. Three or four pens may be placed on each side.

The remainder of the deck is clear, but there is a booby-hatch over the main hatch, through which access is gained to the bait-room.

The haddock catchers do not ordinarily carry davits or a reefing-plank. The mainsail is provided with an "out-hauler" or patent reef-gear, which answers the purpose of a reef-tackle and earing, and facilitates the process of reefing from the deck. A few of the larger vessels, however, are provided with davits and reefing-planks.

The arrangement of the hold is also peculiar. The space which in a halibut catcher is occupied by the forward ice-house is here taken up by the bait room. The bait-room is sometimes, but not always, bulkheaded off from the fore hold. It is one large compartment, with rough board benches all around, on which the men sit while baiting their trawls. In the center stands a stove. In this room the fishing-gear is always stowed when not in use. The after hold is generally fitted up with pens resembling those in the after hold of a halibut schooner. In these pens ice is carried when the vessel is making long trips. When large fares are obtained, part of the fish are stowed in the bait-room, which, on the larger vessels, is so arranged that partitions can be built in it by sliding boards into grooves. The haddock schooners carry a larger amount of ballast than those of any other class; a vessel of 50 tons requiring 30 or 35 tons of ballast.

THE APPARATUS AND METHODS OF THE FISHERY.

Dories.—The larger haddock catchers carry six dories, the smaller four or five.* Most of the dories used in this fishery are deeper and wider than those in any other fishery, and are built specially for the purpose. The ordinary dory is also frequently in use. These dories are 14 feet in length. When on deck they are nested in the ordinary manner, two or three on a side, and are stowed nearly amidships on each side of the booby-hatch, not nested close to the rail, as is the practice upon other vessels carrying dories. A haddock dory ready to leave the vessel in order to set its trawl is provided with the following articles in addition to the trawl-lines: Trawl-roller, two pairs woollen nippers, dory-knife, gob-stick, gaff, bailing-scoop, thole-pins, two pairs of 9-foot ash oars, buoys, buoy-lines, anchors, and black-balls.

Trawls.—The haddock trawls have the ground-line of tarred cotton, of 14 to 18 pounds weight to the dozen lines of 25 fathoms each in length. Hemp is occasionally used, especially by the Maine vessels and by some of the Irish vessels from Boston. The gangings are of white

*The haddock-catchers of Maine and some of the ports in Massachusetts, fishing with "single dories," carry one for each man besides the skipper and cook. These boats are 13 feet long, and managed by a single fisherman.

or tarred cotton, in weight about 4 to 6 pounds to the 300 fathoms of line. They are about 2 feet in length, and are fastened to the ground-line at intervals of 3½ feet. The manner of fastening the gangings to the ground-line is different from that upon the halibut trawls.* The hooks are numbers 15 or 16, center draught, and eyed.† The hooks are fastened to the gangings in the same manner as on the cod trawls. The haddock trawls are coiled in tubs, similar to those employed in the Georges fishery. A flour barrel, sawed off above the lower quarter hoops, is used for a tub. Each tub of haddock trawl contains 500 hooks, or about 292 fathoms of ground-line. Each dory is provided with six or eight tubs of trawl, and two to eight of these tubs of line are set at once, as the case may require. Sometimes only two or three tubs are set at a time, and several sets are frequently made in a day when the weather is suitable.

One of the anchors is similar to those used upon the cod trawls, while the second anchor is often of the killick pattern. The buoy-line is the same as in the cod or halibut trawl, and its length is 15 to 30 fathoms more than the depth of water in which it is used. The buoys are similar to those used in cod-trawling. Each buoy at the end of the trawl has a black-ball upon it, and a middle buoy, without a staff or black-ball, is also used‡ when the whole length of the trawl is set.§ Instead of the regulation keg buoy, a "kit" is sometimes used by the haddock trawlers.

Bait.—When it can be obtained, the principal bait used by the haddock-catchers is menhaden slivers, salted. This is considered the best bait, and it is said that haddock will often bite at this when nothing else will tempt them. The trawl-hooks, when this bait is used, may be baited days, or even weeks, in advance, while the vessel is waiting for a chance to set. When fresh bait is used, the trawls can be baited only a short time before, indeed, only a few hours before they are to be set.

Fresh herring is also used for bait, though to a comparatively limited extent, until within the past two or three years, when they have been the principal bait relied upon, as a sufficient quantity of menhaden could not be procured.

Capt. S. J. Martin, of Gloucester, writes: "Five or six years ago pogie slivers were exclusively used for bait by haddock fishermen, but for the past two winters none of these could be obtained, and mackerel and herring have been the principal bait. The first vessels that started

* They are fastened either by tucking and hitching or by a simple hitch around the ground-line.

† The Irish fishermen of Boston sometimes use a galvanized hook of the same size without an eye.

‡ This is to aid the fishermen in recovering their trawls in case they are parted at either end.

§ When the trawls are set in shallow water where there is a rocky bottom three or four middle buoys are sometimes used.

in October (1880) took fresh mackerel for bait. When the herring came on the coast, or were brought to Gloucester frozen, they were the bait depended on by the haddock catchers."

In cutting up menhaden slivers for haddock bait, sections are made trapezoidal or square in form, with a surface area of about a square inch. One of these pieces is placed on each hook, and as the hooks are baited the line is coiled in the tub, the hooks being placed around on the side, points up.* When the fisherman is ready to bait his trawl he sits upon his bench with the empty tub between his legs and the trawl-line removed from the tub and turned right side up in front of him, his bait being in a bucket at his side. In his left hand he takes eight or ten pieces of bait, and with both hands he pulls the line towards him, coiling it in the tub after baiting the hooks; he places them in the tub in the manner just described.

As is always the case where a number of men are working together at the same employment, there is sharp competition among the men as to who shall be the first to get his trawl baited. The average time consumed in baiting 500 hooks is from 45 to 60 minutes, though the most skillful men have been known to accomplish the task in half an hour. It will be seen that the labor of baiting three or four tubs, which falls daily to each man when the fishing is good, occupies a considerable portion of the day, or, rather, of the night, since the baiting is usually done at night. In baiting at night each man has a lamp of peculiar pattern which is fastened to the edge of his tub by a hook; sometimes the trawls are snarled, and the whole night is devoted to clearing and baiting them. A man will go into the hold to bait after the fish are dressed in the evening and perhaps not finish his task until daybreak, when it is time to go out to set again.

Methods of fishing.—As has been remarked, the haddock catchers never anchor on the banks when fishing. The usage in this respect has greatly changed within the last few years. When the fishery was less extensive and was carried on entirely upon the inshore grounds they were accustomed to anchor, set their trawls and under-run them, but now the trawls are all set while the vessel is lying to waiting for the dories. This operation is called "setting under sail," and its successful performance is one of the most complicated evolutions performed by vessels and boats, requiring a high degree of skill on the part of the men on the vessels and in the boats.

Let us imagine ourselves on the deck of a haddock schooner at daybreak approaching Jeffries Ledge; the skipper, having first sounded and obtained the desired depth of water, decides to make a set and gives the order, "Get the top dories ready," at the same time indicating how many tubs he thinks it desirable for each dory to set. The four men to whom the two top dories belong adjust the anchors, buoy-lines

* The Irish fishermen of Boston place their trawls in baskets, coiling the line in one part and putting the baited hooks in another division of the basket.

and buoys which are already in the dories, and also place in them the other necessary fishing-gear. The dory-tackles are then hooked on, and the boats are swung over the side of the vessel. The middle dories are then equipped in a similar manner by their respective crews, and as soon as these are ready the top dories are dropped into the water and paid astern and the middle ones are swung over the side, the bottom dories being then prepared for action in their turn. The middle dories are now dropped down and paid astern with the others, and the bottom dories are swung upon the sides and are ready to be lowered at the proper moment. Eight men take their places in the dories towing astern; perhaps, in fact, the four men belonging to the top dories are already there and ready to set.

The skipper now gives the order to one of the dories that was first put out, "Throw out your buoy." This being done the dory tows astern of the vessel until the buoy-line runs entirely out; the men in the dory then sing out, "Let go the painter." The dory is cast off and they begin to set their trawl in the ordinary manner, their course usually being to leeward, and nearly at right angles with the direction of the vessel. This operation is repeated in succession with each boat: the last dories dropping astern after the others have been let go. Sometimes when the wind is moderate and it is practicable, all six dories are dropped down before the first begin to set. The boats having been let go in the manner described, are thus left scattered along in the wake of the schooner at intervals of 100 to 200 fathoms, the first and the last dory being from three-quarters of a mile to a mile and a half apart. As soon as the dory has been dropped, the vessel keeps off and runs to leeward and is ready to pick up the first one as soon as her trawl has been set, and the others in regular succession. The time occupied in setting the trawls under sail varies from half an hour to an hour.

When the dories are picked up, a part or all of them are taken on deck and the vessel immediately begins to work back towards the weather buoys; as soon as the weather buoys are reached, the boats are usually dropped again in the manner already described and the men begin hauling. This second evolution occupies from one hour to an hour and a half, according to the strength of the wind and other circumstances. As the dories are dropped a second time they find themselves at the very place where they threw overboard the first anchor and a mile or two to the windward of the place where they dropped their last anchor. They are now able to haul to the leeward, which is easier than hauling to the windward and is more advantageous to the fishing, since the tender-mouthed haddock are less liable to drop from the hooks of a trawl when it is slack than when it is taut.

For the dories to haul their trawls occupies from one to four hours, according to the length of the trawl, the number of fish on the hooks, and the state of the weather. While the dories are hauling, the vessel is lying-to with the jib to windward and drifting back and forth along

the line of boats, waiting for the men to finish hauling their trawls or signalize, by raising one of the oars, that they have a load of fish and wish to be taken on board. After the lines have all been hauled the dories are again taken on deck, unless another set is to be made on the same ground. When the dories set the whole length of lines it is very unusual for a vessel to make more than one set in a day; sometimes, however, a smaller number of lines is set and the operation is twice performed. In exceptional instances, after the whole string of tubs has been once set, a smaller number, perhaps a tub to each man, is set in the latter part of the day.

The operation of shooting alongside of the dories and picking them up is one of the most difficult feats of seamanship which can be accomplished by a fishing schooner.

The haddock trawls are often set in rough weather and at times when there is what would be called a strong whole-sail breeze, and, occasionally, when it blows hard enough to make it necessary to reef the sails. After the trawls have been set and the vessel worked back to the weather-buoys, if the weather looks at all threatening, it is customary to take the bonnet out of the jib and put a reef in the mainsail, so that if the wind should increase while the trawls are being hauled the vessel can be managed by the skipper and the cook—the only men left on board.

As might be expected, men are sometimes lost in this method of fishing, the losses being occasioned by sudden snow-storms which cut the dories off from the view of those on board of the vessel, or by heavy squalls which render it impossible for the schooner with only two men on board to go through the necessary evolutions.

It should be stated that the evolution of setting under sail is varied at different times and by different skippers, but that the differences in the manner of performing the evolutions are not of much importance, and that the most common method is that which is here described.

When fishing on George's Bank, the Gloucester haddock vessels are obliged by the force of the tide to resort to another method of setting, which is called "double-banking the trawl." The tide is so strong that the trawls cannot be set in the ordinary way, for the buoys would be carried beneath the surface. Two dories are therefore lowered at once, and jointly perform the act of setting; only two tubs are set by each pair of dories. The set is made in the following manner: The men in one of the dories hold fast to the weather-buoy while the men in the other dory set the trawl. After the trawl is out, the dory which sets it holds fast to the lee buoy until by some signal, such as lowering the jib, the skipper of the schooner gives the order to haul. The trawls are left on the bottom 15 or 20 minutes before they are hauled. The men in the two dories begin to haul simultaneously; the anchors are thus first raised from the bottom and presently the bight of the trawl and the two boats drift along with the tide, the distance between them gradually narrowing as they haul.

Haddock are often found so plenty on George's that it is not nec-

essary to set more line at a time, even were it easier to do so, since a single tub of trawl will often bring up enough fish to fill a dory. Several sets of this kind can be made in a day, when the weather is favorable.

Some of the Maine and Swampscott vessels send out only one man in a dory; this usage is called "fishing single dories," and is, of course, practicable only in comparatively moderate weather.

THE MANNER OF CARING FOR THE FISH.

As the fish are brought alongside they are pitched into the pens already described. As soon as the dories are discharged and taken on deck, and the vessel is under way, the men begin to dress the fish. The process of dressing differs entirely from that of dressing cod; there are no dressing-tables or dressing-tubs. The men distribute themselves among the pens. Four or five men are engaged in ripping the fish, this operation being performed by seizing the fish by the eyes or some part of the head with the left hand and ripping them downward from the throat. The remainder of the crew occupy themselves in taking out the livers and roes, which are saved in barrels separately, and in removing the viscera. The fish are washed by pouring buckets of water over them as they lie in the pens or on deck, and are packed away in the hold or left on deck, unless, on account of distance from the land or mildness of the weather, it is necessary to ice them, in which case two or three men go into the hold and stow the fish away between layers of ice. The fish are iced with greater or less care, according to the length of time expected to elapse before the arrival of the schooner at the market. All the vessels going to Le Have, George's and Cape Negro carry from five to six tons of ice each trip.

PRODUCTIVENESS OF THE FISHERY.

The vessels of the Gloucester fleet, in the winter of 1880–'81, obtained on an average 350,000 pounds of haddock, valued at $6,000. The schooner "Martha C." obtained about 600,000 pounds, stocking $11,500. The "Edith M. Pew" obtained 550,000 pounds, stocking about $11,000.

Capt. S. J. Martin, of Gloucester, Mass., writes under date of February 12, 1882, that the schooner "Martha C." arrived yesterday with 90,000 pounds of haddock; she was gone eight days. Schooner "Josie M. Calderwood," 85,000 pounds, gone seven days. Schooner "H. A. Duncan," 80,000 pounds, gone seven days. Four vessels left Gloucester on Saturday and were back on Wednesday, each with 40,000 pounds haddock, having fished one day-and-a-half. That is good and quick work.

"Schooner 'Mystic,' Capt. John McKennon, has stocked the year ending February 8, 1882, $21,003. He claims high line of the shore haddocking fleet, and so far as we know this is the largest stock ever reported in this fishery. The crew shared $780.06. In 1880 he stocked

$17,765, the crew sharing $765."—[Cape Ann Advertiser, February 10, 1882.

"The new schooner 'Dido,' recently built at Essex for Mr. George Steele of this city, has been engaged in the haddock fishery just one month to-day, during which time she has made three trips, stocking $3,750. On her last trip she stocked $1,400. Her crew shared for the month, $138 each. The 'Dido' is commanded by Capt. William N. Wells. Schooner 'Richard Lester,' Capt. Ozro B. Fitch, on a recent haddock trip stocked $1,100."—[Cape Ann Advertiser, February 10, 1882.]

The largest haddock fare ever landed was that of the schooner 'Martha C.' of Gloucester, Capt. Charles Martin, which arrived at Boston on Friday from a Georges haddock trip, and weighed off 93,000 pounds haddock, stocking $1,943, the crew sharing $91, the result of two-and-a-half days' fishing. Absent ten days. This was the largest catch and best stock ever reported in the haddock fishery.—[Cape Ann Advertiser, February 24, 1882.]

The catches of the average Portland and Boston vessels were not, probably, more than half as great. The "Martha C.," before alluded to in thirteen hours' fishing in the winter of 1880–'81 caught 90,000 pounds of cod and haddock. The total amount of haddock carried into Boston in 1870 was 17,000,000 pounds; of this amount probably at least 13,000,000 were obtained by the winter haddock vessels. The total yield of this fishery does not, probably, fall below 18,000,000 to 20,000,000 pounds.

RUNNING FOR THE MARKET.

No class of vessels, not even the halibut schooners, take more risks in running for market than do the haddock schooners. It is of the utmost importance to them to reach the market with their fish in good condition, and, if possible, to be in advance of other vessels engaged in the same business. In the stormiest of weather all sail that they will bear is crowded upon them, and harbors are made even in heavy snow and fog. The trips are short, averaging frequently not more than two or three days, and rarely longer than a week or ten days; they are, therefore, constantly running for the land, and are more accustomed to making the coast than the halibut vessels, and become so familiar with the harbors, most frequently resorted to, especially with that of Boston, that they are able to enter them when no other vessels, probably not even pilot boats, would care to make the attempt. What has already been said about the dangers encountered by the halibut schooners will apply as well, in its fullest extent, to the haddock schooners.

THE MANNER OF OUTFIT.

In the winter haddock fishery every man supplies his own dory and outfit complete, besides paying his share of the provision bill. In the settlement of the voyage, the vessel draws one-fourth of the net stock,

or, in the case of the older vessels, according to the old system, only one-fifth, after certain stock charges have been deducted for bait, ice, wharfage, and towage. The remaining three-fourths or four-fifths of the net stock is divided equally among the crew, the owner paying the skipper's commission or percentage from the vessel's quarter. The average share of the Gloucester crews for the winter of 1880–'81 was about $290. The most successful shared $500 to $550. The largest stock ever made in one day's fishing in the winter shore fishery up to 1880 was that of the "Eastern Queen," of Gloucester, which carried to the Boston market, in 1873, 25,000 pounds of haddock, and stocked $1,100. This vessel also made the largest stock of that season, realizing in five months $10,250 clear of all expenses, the crew sharing $550 each. The crew of the schooner "David J. Adams," in March, 1881, shared $107 each in a ten days' trip in the haddock fishery

THE HADDOCK FISHERY FIFTY YEARS AGO.

A writer in the Fishermen's Memorial and Record Book thus describes the haddock fishery in the early part of the present century:

"The fitting-out of the fleet for the haddock fishery commenced about the first of April. The first move was to run the boats on the beach, or landing as it was then called, and have them calked and graved. The latter process consisted in applying a coat of pitch to the bottom and burning it down with a tar-barrel, which gave a smooth and glossy surface. Painted bottoms in those days were very rare.

The time occupied in making a haddock trip was from two days to a week, the fish being mostly taken on Old Man's Pasture, Heart's Ground, and Inner Bank, about twelve miles off of Eastern Point. The fish were taken to Charlestown for a market, and purchased by the hawkers—among whom were Johnny Harriden, Joe Smith, Isaac Rich, and others, who took them over to Boston in hand-carts and retailed them at a good profit. The codfish were generally salted. The smallest were cured for the Bilboa market, and the largest were made into dun fish, as they were called, for home consumption. They were kept on the flakes several weeks, and thoroughly dried until they became of a reddish color, and were highly esteemed as an article of food. The haking season commenced in July, and the pollock fishery was prosecuted from September to the middle of November. Each boat carried three men—skipper, forward hand, and cook, who went at the halves, as it was called, the crew receiving one-half the gross stock, and the owners the balance."*

* Fishermen's Memorial and Record Book, Gloucester, 1873, p. 73.

THE PROTOZOA AND PROTOPHYTES CONSIDERED AS THE PRIMARY OR INDIRECT SOURCE OF THE FOOD OF FISHES.

By JOHN A. RYDER.

In the course of observations made during the last few years the writer has been more and more impressed with the importance of the Protozoa and Protophytes as an indirect or primary source of much of the food consumed by man. This is notably true of what is known as fish and shell-fish food. As very striking instances of the truth of these propositions, we need only to allude to the various edible species of the herring family, the shad, herring, and sardine, the gill-rakers of which are modified so as to enable them to strain the minute living organisms out of the water which is passed through the mouth in respiration; the menhaden or *Brevoortia*, which is of the same family and swarms along our coast, and which in its turn furnishes a large proportion of its food to the edible bluefish, and so serves this tyrant of the sea as a strainer, elaborator, and accumulator, as it were, of the minuter life of the oceanic wastes which it inhabits. The oyster, in like manner, subsisting, as it does, entirely upon Protozoa, Diatoms, minute ciliated larvæ, &c., reminds us forcibly that for some of the most savory luxuries of the table we are indirectly indebted to the existence of countless hosts of living marine beings, which can be rendered visible only with the help of a microscope.

Comparatively few fishes appear to be able to utilize the protozoa directly as a source of food. The most remarkable exception to this rule was first made known by Professor S. A. Forbes, of Illinois, who found the intestines of certain young suckers or *Catostomidæ* packed with the shells or tests of difflugian rhizopods. In the Proceedings of the Academy of Natural Sciences of Philadelphia for 1881, Professor Leidy states that upon examining two slides containing some of the intestinal contents of young *Myxostoma macrolepidotum* and *Erimyzon sucetta* submitted to him for examination by Professor Forbes he was able to distinguish the shells of six distinct species of rhizopods or test-covered amoeboid Protozoa. The habits of the fishes in question are, however, mud-loving, and, since they are provided with a more or less suctorial mouth, it is easy to understand how they might readily consume large numbers of these Protozoans where the surface of the ooze of the bottoms of the streams and pools inhabited by the fishes was favorable to the propagation and healthy existence of the former.

In order to render the vast multitude of Protozoa available as fish-food it is necessary that they be consumed by larger organisms, which in their turn may be consumed by the fishes. Upon investigating the literature relating to the food of the smaller crustaceans, especially of the Entomostraca which enter so largely into the food supplies of most

young fishes and very many adult forms, I find that the almost unanimous testimony of various observers is to the effect that these creatures are largely carnivorous, and subsist mostly upon protozoa, or the lowest grade of animal existence. In proof of the foregoing, the following extracts are here introduced.

In his Natural History of the British Entomostraca, page 6 of the introduction, Dr. W. Baird remarks: "I have no doubt that most of the entomostraca are essentially carnivorous, and I have frequently seen specimens of *Cypris* in their turn, as soon as dead, attacked immediately by quantities of *Cyclops quadricornis*, which in a few minutes had fastened themselves upon the dead animal, and were so intent upon their prey that they were scarcely frightened away from it by being touched with a brush. In a short time the *Cypris* might be seen lying at the bottom of the vessel, the valves of the shell separated and emptied of its contents. Leeuwenhoek and De Geer not only maintain that the *Cyclops quadricornis* lives upon animalcules, but that it even preys upon its own young, a fact which I have also noticed myself. Jurine asserts that the *Cyclops quadricornis* is carnivorous from taste, and only herbivorous from necessity; while the *Daphnia pulex*, he distinctly affirms, lives upon animalcules. Place a few Entomostraca, such, for example, as the *Daphniæ*, *Chirocephali*, *Lyncei*, &c., in a vessel with pure, clear water, and only some vegetable matters in it, and they gradually become languid, transparent, and finally die; but mix with this water some which contains numerous Infusoria, and the Entomostraca will then be seen speedily to assume another aspect. They become lively and active, and the opacity of their alimentary canal testifies sufficiently the cause of it. When, indeed, we consider the amazing quantity of animals which swarm in our ponds and ditches, and the deterioration of the surrounding atmosphere which might ensue from the putrefaction of their dead bodies, we see a decided fitness in these Entomostraca being carnivorous, thus helping to prevent the noxious effects of putrid air which might otherwise ensue; whilst they in their turn become a prey to other animals which, no doubt, serve their purposes also in the economy of nature."

"The food of the *Lynceidæ*," says Baird, "consists of both animal and vegetable matter, and while they prey upon animalcules smaller than themselves, they, in their turn, are devoured in great numbers by insects larger than they are."

According to Pritchard, the *Chyodorus sphaericus* is the choice food of a species of fresh-water *Nais* which he calls Lurco. "So great is the voracity," he says, "of this creature that I have seen a middle-sized one devour seven *Lyncei* in half an hour."

Referring to the *Daphniadæ*, our author again observes: "The food of these animals, according to Straus, consists of vegetable matter, and not animal; but I have found that of two groups placed in separate vessels of clear water, the one having only particles of vegetable matter

placed beside them, while with the other there were also introduced infusorial animalcules, the latter were much stronger, more active, and throve better than the former."

This appears to be very strong evidence in favor of the animalcular diet of these crustaceans. Other evidence, too, of quite as convincing a character is not wanting. Those who have been in the habit of collecting quantities of microscopic material from ponds and ditches have frequently observed very large schools of Entomostraca in such places where the water as a rule is not absolutely stagnant, but where an abundance of duck-weed, fresh-water algæ of many kinds, as well as various water plants of the higher orders make a splendid nidus for all kinds of monads and ciliated and amoeboid Protozoa. These are the places where *Cyclops*, *Daphnia*, and allies flourish inland in fresh water. The writer has also noticed them particularly abundant in the wide river flats near the mouth of the Susquehanna at Havre de Grace, where there are large areas many acres in extent which are covered with a luxuriant growth of *Potamogeton*, *Anacharis*, and *Vallisneria*, making a dense mat of delicate stems and leaves upon which countless multitudes of Protozoa may fix themselves and abide. If, in rowing through such masses of aquatic vegetation, one will stop the boat and stir carefully among the plants with the hand over the side and cautiously watch the result, one will often notice that great numbers of Entomostraca have been frightened from their leafy retreats. These are the places where young shad ought to be liberated; in such places they would find an abundance of food at an early period, or as soon as they were fitted to partake of nutriment by swallowing.

Just as we find the fresh water forms of Entomostraca take to the shelter of aquatic vegetation at the mouths of rivers, so it appears that many of the marine forms seek protection, and probably food, under cover of the fronds of marine algæ. Here is what their most recent monographer says in relation to this point: "A large number of species haunt almost exclusively the forests of *Laminariæ* which grow on rocky coasts at and below low-water mark; the fronds of *Laminaria saccharina* in particular are the favorite abode of many species." (Brady, Monog., Brit. Copep., Introd. I, p. 7.) Again, on page 9, he remarks, "The washing of the fronds and roots of *Laminariæ*, which may be dragged up by means of the hooked grapnels used on many coasts by kelp-burners, often affords multitudes of Copepoda."

They appear in many cases to be surface swimmers. I have myself seen schools of several thousands of *Daphniadæ* of a greenish yellow color in the ditches south of Camden, N. J., swimming at the surface of the water at midday in the bright sunlight. In the vicinity of Woodbury, in the same State, my friend, Mr. W. P. Seal, has taken great numbers of a bright red-colored Copepod, apparently related to the genus *Pontella*, and perhaps undescribed. They were sufficiently abundant in some cases to impart a red tinge to the water.

Brady (Monograph British Copepoda) observes in his introduction, vol. i, page 9: "The beds of fresh-water lakes seem to be very sparsely populated with Copepoda, and as to swimming species it may, as a general rule, be said that the weedier the pool and the smaller its extent, the more abundant in all probability the Entomostraca.

"Many of the marine species pass their life apparently near the surface of the open sea, and some of these, such as *Calanus finmarchianus*, Gunner, and *Anomolocera Patersonii*, Templeton, are frequently found in immense profusion, the first-named species having been said to form a very important part of the food of the Greenland whale, and it is remarkable that in the Arctic seas not only do the Entomostraca attain an enormous development in point of numbers, but also in individual size; Arctic specimens, for example, of *Calanus finmarchianus* and *Metridia armata* being many times the bulk of those taken in our own latitude." (*l. c.*)

According to H. Woodward, in his article Crustacea, Encyclopædia Britannica, the fecundity of the Copepoda is truly surprising. "*Cyclops quadricornis* is often found with thirty or forty eggs on each side, and though those species which have but a single ovisac do not carry so many, their number is still very considerable. Jurine isolated specimens of Cyclops, and found them to lay eight or ten times within three months, each time about forty eggs. At the end of a year one female would have produced 4,442,189,120 young! Cetochilus is so abundant, both in the northern seas and in the South Atlantic, so as to serve for food to such an immense animal as the whale. They color the sea for many miles in extent, and when the experienced whaler sees this ruddy hue upon the ocean he knows he has arrived at the 'pasture of the whales'. They are to be seen in vast quantities off the Isle of May in the Firth of Forth during the summer months. Many Cetacea are attracted thither, and vast shoals of fish also come to feed upon them. One anomalous type of free copepod is the *Notodelphys ascidicola*, described by Allman, which is found swimming freely in the branchial sack of *Ascidia communis*."

The writer, in passing, would remark that he has frequently met with Copepoda swimming freely in the ventral part of the branchial space of *Mya arenaria*, in which the animals were probably not parasitical or commensal, but had been drawn from without into the respiratory space of the mollusk through the incurrent part of its siphon.

In the same article as previously quoted Woodward observes: "The Cladocera are chiefly fresh water, and are distributed over the whole world. Of this order the *Daphnia pulex*, so abundant in our [British] fresh waters, is a good example. So numerous are they in our ponds in summer as frequently to impart a blood-red hue to the water for many yards in extent. In order to realize the wonderful fecundity of this and allied genera, it is necessary to realize that when a *Daphnia* is only ten days old eggs commence to be formed within the carapace, and under

favorable conditions of light and temperature it may have three broods a month, or even a greater number, the larger species having as many as forty or fifty eggs at once."

The remarkable fecundity of the Copepoda explains the extraordinary abundance of the free-swimming species upon the high seas, and even bays, where vast schools of these crustaceans become, in turn, the food of vast schools of herrings, menhaden, and shad. Doubtless, the movements of these fishes on the high seas are determined by the abundance of their favorite food in various localities; that, like the whale, they seek their marine pasture of crustaceans, as argued by Möbius. Even larger forms of fishes, such as the huge basking shark (*Cetiorhinus maximus*), has its branchial apparatus adapted to capture small pelagic organisms, in the same way as the Clupeoids. The prodigious numbers of herrings and menhaden is a proof of the abundance of the minute pelagic organisms upon which, with scarcely a doubt, it may be supposed they subsist. It is also not improbable that the vast schools of pelagic Entomostracans are in pursuit of still smaller protozoan prey, upon which they subsist and maintain their marvellous reproductive powers. Moseley, in his "Notes by a Naturalist on the Challenger," observes: "The dead pelagic animals must fall as a constant rain of food upon the habitation of their deep-sea dependents. Maury, speaking of the surface Foraminifera, wrote, 'The sea, like the snow-cloud, with its flakes in a calm, is always letting fall upon its bed showers of microscopic shells.'" Moseley records that he estimated, from experimental data, that it would take four days and four hours for a dead *Salpa* to fall to the bottom where the sea was 2,000 fathoms in depth. The deep-sea fauna is probably well supplied with food from such sources. The researches of Mr. John Murray of the Challenger fully confirm and greatly expand the significance of the views of Lieutenant Maury in relation to the destiny of the marine foraminiferal shells. Wyville Thompson, Voyage of the Challenger, I, 210, observes: "Mr. Murray has combined with a careful examination of the soundings a constant use of the tow-net, usually at the surface, but also at depths from ten to a thousand fathoms; and he finds the closest relation to exist between the surface fauna of any particular locality and the deposit which is taking place at the bottom. In all seas, from the equator to the polar ice, the tow-net contains *Globigerinæ*." Some of these surface Foraminifera are relatively large, *Orbulina universa* being as much as a fiftieth of an inch in diameter, and hence of a sufficient size to be preyed upon by a larger arthropod. The remarkable *Pyrocystis noctiluca*, discovered by Mr. Murray, and nearly a millimeter in diameter, is another interesting surface form, as is also the *P. fusiformis*, which is allied to it. Both are phosphorescent surface swimmers, and fall within the reach of other surface animals as a probable source of food. To these may be added the curious group of the *Challengerida*, together with the whole of the *Radiolaria*, with their siliceous shells, which, in the warmer parts

of the high seas, actually tinge the surface when some of the highly-colored forms are abundant. From the surface of the mid-Atlantic the Challenger crew obtained stalked infusorians fixed to the shell of *Spirula*, also an abundance of large radiolarians. Haeckel, Monograph of the Radiolaria, says the largest living Radiolaria measure only a few lines in diameter, but most of them are much smaller, and attain scarcely a tenth, down to a twentieth of a line in diameter. At Saint Jerome's Creek, Maryland, in an arm of the former, now used as an oyster park, the writer found an abundance of a fresh-water Heliozoan, not specifically distinguishable from *Actinophrys sol.* They were found in great abundance at times on the surface of the slate collectors which had been put down for the purpose of enabling the free-swimming fry of the oyster to fix itself. This raises the question whether the fresh-water protozoan fauna does not overlap the marine. The water in the situation mentioned was not simply brackish, but positively salt. In the same place great numbers of stalked and tube- or test-building ciliate forms of Protozoa were also found. The magnificent bottle-green *Freia producta* was found in the same locality in the greatest profusion. Sometimes several hundred might have been counted on a single square inch of the surface of oyster shells, slates, or boards, giving such surfaces a dark-greenish or speckled tint from their numbers. Very small species of nudibranchiate mollusks (*Eolis* and *Doris*) were found creeping amongst and over the forest of Protozoa, pasturing off of them. Amongst the tubes of the *Freia*, and attached to them, a small operculate *Cothurnia*, with a rich brown-colored test, was found in abundance, and, rarely, a very curious form of *Tintinnus*, with a tubular, subulate test, to the inside of which the stalk of the inhabitant was attached, at one side, about half way up from its base. The open, or mouth, end of the perfectly hyaline test was very strongly toothed, or serrate. The species may be named *Tintinnus Fergusonii.* Another species of *Freia* has been detected, on the coast of New Jersey, by Professor Leidy, and, from a verbal description given me by Dr. H. C. Evarts, a species occurs in the vicinity of Beaufort, N. C. So abundant was *Freia producta* in Saint Jerome's Creek that I apprehend that in its free-swimming young state, previous to the time that it commenced to build its test, it afforded not an inconsiderable proportion of food to the oysters planted in some parts of those waters. Besides the *Freia* there were innumerable individuals of *Vorticella* observed. One of these had a very thick, brownish cuticle; but for numbers these were again very greatly exceeded by the compound stalked genera of bell-animalcules. Upon the very common alga, *Laminaria*, these were abundant, and upon the fronds of another alga, the *Grinnellia*, in three or four fathoms of water, near the middle of the Chesapeake, their number was truly astounding. In a few such places where these algæ were dredged up from the bottom, covered with innumerable colonies of protozoans, it would doubtless be much within bounds to state that there were 1,000 individual protozoan

zoöids to the superficial square inch of frond surface. At this rate there would be 39,204,000 zoöids found to populate a single square rod of frond surface. Estimating the number at only 100 per square inch, which is low, and which would, I think, represent a fair average over considerable areas where the conditions of life were favorable, there would still be a stalked protozoan population of nearly four millions to the square rod. The most abundant of these compound forms was one which very much resembles *Zoöthamnium alternans*, Claperède, found on the west coast of Norway. The same form was again found in vast abundance upon algæ in Cherrystone River, near the mouth of the Chesapeake, during the season of 1881. Upon one occasion I found it in great abundance growing on all parts of the body of a *Pinnotheres* which was living in the gill-cavity of an oyster, its swarmers, or young, as they were thrown off, in all probability forming part of the food supply of the mollusk.

I have been interested upon several occasions to observe that the very minute stalked collared monads, *Salpingœca* and *Codosiga*, are frequently to be found attached to the stems of the compound colonies of bell-animalcules, or gathered about in the vicinity of the point of attachment of a single one. In such cases the monads appear to derive a benefit from the currents or vortices set up in the water by the waving of the ciliary crowns of their giant neighbors, which bring particles of food to their very doors as it were. On one occasion I found individuals of a species of *Vorticella* fixed to the egg-membrane of the ova of the cod-fish at Wood's Holl, Massachusetts, as had been previously observed by R. E. Earll, and in their vicinity were several colonies of a compound stalked monad, resembling the *Dinobryon* of Ehrenberg. On another occasion I found something like *Poteriodendron* on the *Zoöthamnium* which covered a *Pinnotheres* inhabiting an oyster; but the chain of parasitism did not stop here, for on the monad, as well as on the bell-animal, there were rod-like bodies attached which were presumably bacteroid, as has been supposed by Stein. Stalked monads are probably much more common than has been supposed, which reminds me that I have detected the occurrence of *Rhipidodendron splendidum* in the bogs and ponds of New Jersey, a form which was described originally by Stein from Bohemia. Minute as the stalked monads are, they must live on still minuter beings, probably upon the Microbia, which in their turn become an indirect source of supply of food for the grades next above them, such as the free and fixed ciliate Protozoa, which feed upon monads which have themselves fed on Bacteria or Bacillus-like organisms, and so onward the matter of life takes its upward way.

The process of swallowing of many ciliate infusorians is as peculiar as it is interesting. An opening, oftenest at one side of the body, is the mouth, from which a short blind canal passes into the soft substance of the animal's body. The rapid vibration of rows of cilia in the vicinity of the mouth creates currents which set in in the direction of the throat,

the lower end of which is dilated into a globular space by the force of the currents produced by the cilia, in which the particles of food are rotating in the contained water. This space enlarges gradually until eventually its connection with the throat is suddenly broken by a collapse of the walls which join the globular space with the former. In this way food-vesicle after food-vesicle is taken into the body of the animalcule, from which the creature will abstract whatever is useful and cast out near the mouth whatever is contained in the food-vesicles that is indigestible. The writer has seen the process in a number of forms, and it is not unusual to observe a dozen or more food-vesicles in the body of a single protozoan. Many parasitic forms, however, are mouthless, such as *Opalina*, *Benedenia*, *Pyrsonympha*, *Trichonympha*, &c., where the nourishment is probably obtained from their hosts by transudation through the body-walls. In other forms again comparatively large objects are swallowed with apparent ease, judging from shells of other protozoan types which are found within their bodies. Such a form I encountered in a slightly brackish water-pool near New Point Comfort, Virginia, during the summer of 1880. It was apparently a very large species of *Prorodon* of an irregular cylindrical form which had in a number of instances swallowed five or six large difflugians, *Arcella vulgaris*, the shells of which remained within the animal to testify to the nature of the food it had been devouring. Some other mode of swallowing such large prey is probably practiced by this large ciliate, very different from the method first described. In the same pool a very peculiar form of hypotrichous infusorian was detected, which was clearly very nearly allied to *Chilodon cucullulus* of Ehrenberg, but the dorsal, non-ciliated side of its body was not gently rounded, but flat with a prominent crenate rim surrounding it; from this peculiarity it may be called *Chilodon coronatus*.

The mode of swallowing their food adopted by the fresh-water rhizopods has been elaborately described in a few instances by Professor Leidy in his splendid monograph of this group, published by the Geological Survey of the Territories. Their food appears to be mainly vegetable, and consists, for the most part, of diatoms and desmids, though a ciliated protozoan or rhizopod was occasionally met with in the body of *Amœba*. The marine rhizopods appear to be herbivorous as well as carnivorous, remains of both Protophytes and Protozoa having been detected in their bodies. *Vampyrella* has been described as almost parasitic upon the clustered frustules of *Gomphonema*.

Some aberrant ciliated forms, like the *Gastrotricha* and *Coleps*, are somewhat peculiar in their organization, and we know little of their feeding habits.

The *Suctoria* or *Tentaculifera*, which are abundant in some places, both in fresh and salt water, appear to be indiscriminately herbivorous, as well as carnivorous. In fresh water I have met with them infesting the back of the common water leech, *Clepsine*, the species being appar-

ently *Podophrya quadripartita*. Of marine forms, I have seen but two that I could regard as distinct from each other; the one, a very common form, is the old and well-known *Acineta tuberosa* of Ehrenberg, with two clusters of suckers. This form I have frequently seen with diatoms which it had seized and from which it was abstracting nutriment. The other form was much larger than the preceding and appears to be identical with the species described under the name *Podophrya gemmipara* by Hertwig. It has the same robust stalk, with the same close transverse annular markings, the same taper, and is similar in the form of the tentacles, which are often irregularly beaded or swollen. I was enabled to observe in part its development, which is also similar to that of the Helgoland species of the North Sea above mentioned. They were found in great abundance on the surface of the fronds of *Laminaria*, together with the *Acineta tuberosa*; not as abundantly, of course, as the *Zoöthamnium*, but in sufficient numbers to make them a very considerable factor in the protozoan life found in the vicinity of New Point Comfort.

The majority of the free protozoa and many monads, such as *Noctiluca*, have scarcely been considered, but enough has been said, I think, to give some idea of the actual importance of the minute animal and vegetable life of the sea to make it clear that there is a most intimate relation of dependence existing between the lowest and the intermediate forms of life. Why is it, for example, that we should find the Copepoda so abundant among the *Laminaria* along the sea-coast? Have we not shown that on the fronds of these algæ there exists, in most instances, almost a forest of protozoan life, upon which these creatures may be supposed to pasture? We do not find the *Laminaria* itself eaten. Again, the foraminiferal and radiolarian fauna of the high seas appears to be, in great measure, a surface fauna, according to the evidence of a number of investigators. This fact appears to have an important relation to the vast shoals of Copepoda observed at the surface of the sea by various naturalists and expeditions. It is not to be supposed, however, from what has been said, that the Copepoda are the only consumers of this vast array of individual protozoa. Cross-sections through the oyster, which the writer has prepared and mounted, show the tests of various genera and species of diatoms mixed among the indigestible earthy matters and sediment which has been swallowed along with the food. It is probable that the oyster swallows and digests many of its own embryos, and not improbably many embryos of such forms as Bryozoa and sponges, besides the diatoms, desmids, and protozoa which make up the most of its food. Ordinarily the contents of the stomach of the oyster are too much disorganized to learn much about what it has recently swallowed, hence we are at a great loss to know just exactly of what all of its food consists; just so with the Copepoda—they themselves are doubtless eaten by other Crustacea, these in turn by others. We saw that *Doris* and *Eolis* pastured upon

the forests of fixed protozoa, just as *Planorbis*, *Lymnaeus*, and *Physa* pasture upon the protozoa, algæ, diatoms, and desmids, in fresh water. The great abundance of Copepoda and Amphipoda is, however, the best evidence of the abundance of still smaller forms adapted to furnish them with food. What multitudes of forms besides Copepoda must largely subsist upon the protozoa and protophytes. Of such groups we may name the Lamellibranchs, Pteropods, Worms, Bryozoa, Porifera, and, doubtless, many Coelenterata. Some of these, notably the Lamellibranchs, could probably not exist were it not for the numerous protozoa and protophytes, upon which, from necessity, they are compelled to feed.

What is true of the fauna of the sea appears to be in an equally great measure true of the faunæ of fresh-water ponds, lakes, and streams. Recently I investigated some *Daphniadæ* which had been kept for some time in an aquarium; to my surprise I did not find any recognizable remains of animal food in the intestine. The latter were, however, entirely filled with a sarcode-like material, doubtless in part a digestive secretion, together with what might have in part been animal food. The vegetable food, consisting of diatoms, unicellular algæ, spores of fungi, fragments of oscillatoriæ, were so sparingly mixed with the intestinal contents that they could not be regarded as contributing much to the nutrition of the animal. The black or brown material, sometimes filling the intestine of Entomostraca, I find to consist in great part of humus, particles of quartz sand and earthy matters, which are of course indigestible, being thrown out of the vent, as in Chirocephali, in the form of cylindrical casts.

The most valuable contribution to our knowledge of the food of the fresh-water fishes of the western United States has been made by Professor S. A. Forbes, in Bulletins Nos. 2 and 3 of the Illinois State Laboratory of Natural History, for the years 1878 and 1880. With the most painstaking care the results of a vast number of examinations are recorded. He finds that the Darters, Perches, *Labracidæ*, Centrarchoids or sun-fishes, Sciænoids, Pike, Bony Gars, Clupeoids, Cyprinoids, Suckers, Cat-fishes, and *Amia*, both the young and adults, consume large numbers of small aquatic, and occasionally small terrestrial organisms, notably the smaller Arthropods. While many of the more voracious species, both young and adult, feed on their immediate allies, the dietary of the fishes of Illinois, according to this observer, includes mollusks, worms, fresh-water Polyzoa, Hydrachnidæ, insects of both mature and larval forms; Crustacea, embracing Decapods, Tetradecapods, Amphipods, Isopods, and Entomostraca of the groups Cladocera, Copepoda, and Ostracoda; Rotifera, Protozoa, vegetable matter, and algæ. In his first paper he also gives a list of the organisms found in the stomachs and intestines of the Pirate perches, *Gasterosteidæ*, *Atherinidæ*, *Cyprinodontidæ*, *Umbridæ*, *Hyodontidæ*, and *Polyodontidæ*. Both are accompanied by elaborate comparative tables, and, in an economical sense,

are of the greatest practical importance in their bearing upon fish culture.

It has, however, been known long ago that fishes consume large quantities of small *Crustacea*, as will be seen from the following extract from Dr. Baird's work:

"That the Entomostraca form a considerable portion of the food of fishes has long been observed, and it is very probable that the quality of some of our fresh-water fishes may in some degree depend upon the abundance of this portion of their food. Dr. Parnell informs me that the Lochlevin trout owes its superior sweetness and richness of taste to its food, which consists of small shells and Entomostraca. The color of the Lochlevin trout, he farther informed me, is redder than the common trout of other localities. When specimens of this fish have been removed from the loch and conveyed to lakes in other places, the color remains, but they very soon lose that peculiar delicacy of flavor which distinguishes so remarkably the trout of Lochlevin. The experiment has been repeatedly tried and always with the same results. The bunstickle [*Gastrosteus trachurus*] devours them with great rapidity, and I have seen two or three individuals clear in a single night a large basin swarming with Daphniæ and Cyclops, &c."

The writer would also refer to articles on the food of fishes in the Reports of the United States Fish Commissioner for 1872 and 1873 by Professors Milner and Smith, and to papers by Widegren and Ljungman on the copepodan food of herring. Also a paper by Dr. C. C. Abbot in the same report, for 1875 and 1876, on the winter habits of the fishes of the Delaware. Möbius has found pieces of algæ, besides shells, snails, crabs, and fishes in the stomach of the cod. The writer has found the stomach of the sheep's-head filled with the remains of the shells of mussels and large quantities of the slender branches of the common bright red sponge, *Microciona proliferum*, bitten off in short fragments by the incisor-like teeth of the fish, and with the red sponge sarcode partly digested out of its skeleton. It is presumed that the sponge feeds upon protozoan life, and on account of its peculiar dentary armature the sheep's-head is singularly well fitted to pasture upon sponges and thus indirectly appropriate protozoa as nourishment. The same remark applies to the molluscan food of this fish.

In young shad from Capehart's fishery, Albemarle Sound, said to have been three weeks old, I found the remains of a number of adult *Tipulidæ*, or crane-flies, in the intestine. This reminds me that in examining the larvæ of crane-flies some years ago, I was struck with the fine comb-like fringes which garnish the edges of their wide oral appendages, and which are so extended in life when the larva is in motion as to constitute a sort of basket which opens downwards and forwards apparently to strain out of the water the small organisms which constitute its food. Here again we have young shad feeding upon an arthropod which has passed its larval existence, feeding in great part upon protozoa. West-

wood, Introd., II, 511, I find, makes a similar observation in regard to the larvæ of the gnat or mosquito family. He says: "The head is distinct, rounded, and furnished with two inarticulated antennæ, and several ciliated appendages, which serve them for obtaining nourishment from their food."

The fixed Tunicates are probably as dependent upon the microscopic life swimming about them in the water as the Lamellibranchs. The Barnacles in like manner, immovably fixed during their adult existence, kick their minute food into their mouths with their filiform legs, as remarked by Huxley. In *Pedicellina americana*, abundant in Saint Jerome's Creek, I have observed that there are rows of vibratory cilia continuous with those of the tentacles around the edge of the lophophore, which appear to lie in grooves, which blend on either side of the excentrically placed mouth. In this manner the microscopic food of this curious bryozoan is conveyed in ciliated grooves to the mouth from all points of the oral disk. With these we may close our survey of the modes in which the protozoan grade of life is appropriated the smaller Arthropods, Pteropods, Polyzoa, Annelids, and Tunicates, but we must remember that upon these again the larger forms subsist, which are either food for each other or for man. As we pass in succession the larger forms, we may note the Lamellibranchiates, with this garniture of vibratory cilia covering the gills and palps, and which carry the particles of food and sediment suspended in the water used in respiration to the mouth to be swallowed. The Clupeoids and Cetorhinus with their branchical sieves are particularly noteworthy for the perfection of the apparatus of prehension, but we must not forget that the gill-rakers of all fishes, whenever developed to any extent, probably subserve a similar function. Lastly, the right-whales, with their closely ranged plates of baleen suspended from the upper jaws, forming in reality a huge strainer or filter for the large volumes of sea-water which pass through the mouth, and from which the food of these marine giants is so simply obtained, will enable us in a measure to comprehend the importance of the minute life of the world, and its indirect but important economical relation to man.

THE FOOD OF THE YOUNG SHAD.

The periods of yelk-absorption.

In a previous paper by the writer on the retardation of the development of the shad, it was stated that the yelk-sack disappeared on the fourth to the fifth day after the young fish had left the egg. Although this statement is in a broad sense true, I find upon more accurate investigation that there is a small amount of yelk retained in the yelk-sack for a much longer time. It appears in fact that there are really two periods of absorption of the yelk which may be very sharply distinguished from each other. The first extends from the time of hatching to the end

of the fourth or fifth day, according to temperature, during which time the most of the yelk is absorbed. The small quantity which remains after this time is not visible externally, being contained in a small fusiform sack, all that remains of the true yelk-sack inclosed by the abdominal walls, and causes little or no visible prominence on the under side of the young fish. Viewed as a living transparent object from the side, we see it in the young fish lying below the œsophageal portion of the alimentary canal immediately in front of the very elongate liver, and behind the heart, with the venous sinus of which it appears to communicate by a narrow duct formed of the anterior portion of the yelk hyboblast, which formerly covered the distended yelk-sack. The appearances presented by the living transparent objects are fully confirmed by the evidence obtained from transverse sections of embryos from ten to twelve days old. It appears that the yelk-sack of the California salmon probably behaves in a somewhat similar manner as indicated by transverse sections. I even find this slight rudiment of the yelk-sack in shad embryos fourteen to sixteen days old, but this seems to be about the period of its disappearance. The second period of the absorption of the yelk therefore extends in the shad over about twice that of the first, or about ten days. The first period extends to the time when the yelk-sack is no longer visible externally, the second from the time the remains of the yelk-sack become inclosed in the abdomen until its final and complete absorption. The function of the yelk-sack during the first period appears to be to build up the structures of the growing embryo; during the second, not so much to build it up as to sustain it in vigorous health until it can capture food to swallow and digest, so that it may no longer be dependent upon the store of food inherited from its parent.

The appearance of the teeth.

Minute conical teeth make their appearance on the lower jaws and in the pharynx of the young shad about the second or third day after hatching. Sections through the heads of embryos show that these teeth are derived from the oral, hypoblastic lining of the mouth. There are none on the upper jaw, there are four arranged symmetrically on the lower jaw, or rather, Meckel's cartilage. In the throat, in the vicinity of the fifth and last branchial arch, there are two rows of lower pharyngeal teeth, the first of six, three on a side, the last of four, two on a side. These teeth are of the same form and size as those on the jaws.

The age at which it begins to take food.

Although peristaltic contractions of the walls of the intestine of young shad may be observed soon after hatching, I have never observed food in the alimentary canal until ten or twelve days after the young fish had left the egg. At about the beginning of the second week considerable may be seen in living specimens. But the intes-

tine is often not yet very densely packed with food even at this period. At the age of three weeks an abundance of food is found in the intestine, that portion which becomes the stomach and which extends from the posterior extremity of the liver to near the vent being greatly distended with aliment. Upon investigating the nature of this food material we learn that it consists almost entirely of very small crustaceans, in reality for the most part of the very youngest *Daphniadæ* and *Lynceidæ;* only once did I find what I thought might be very small *Ostracoda* or *Cypridæ*. In some instances the undeveloped larvæ of *Daphniæ* were noticed. In a few cases green cellules were observed in the intestines of shad larvæ resembling *Protococcus*, but as this material appeared to be accidental, it is probably not an important element of shad food. In the young fishes the dark, indigestible remains of the food of the *Daphniæ* always remained, together with the hard chitinous parts, as long-curved cylindrical casts which preserved the shape of the intestines of the crustaceans. In one young shad, twenty-two days old from the time of impregnation, measuring 14 millimeters in length, I estimated from a series of sections through the specimen that it must have consumed over a hundred minute crustaceans.

The oldest specimens of artificially reared shad which came into my hands were some that had been overlooked in some of the hatching apparatus at Dr. Capehart's fishery in North Carolina, where they remained for three weeks after hatching. In that time they had grown to a length of 23 millimeters, or almost one inch. The air-bladder was more developed and the stomach was more decidedly differentiated than in any previous stage. In the intestines of these I found, beside black, earthy, and vegetable indigestible matter, the remains of the chitinous coverings of small larval Diptera, and the remains of a very small adult crane-fly, besides Entomostraca allied to *Lynceus*. In these specimens the dorsal fin had the rays developed, the continuous median larval natatory folds having by this time disappeared.

The mode in which the young fish capture their Entomostracan prey may be guessed from their oral armature. Most fish larvæ appear to be provided with small, conical, somewhat backwardly recurved, teeth on the jaws. Rathke, in 1833, described the peculiar hooked teeth on the lower jaw of the larvæ of the viviparous blenny, and Forbes has observed minute teeth on the lower jaw of the young *Coregonus albus*. I have also met with similar teeth on the lower jaw of the larval Spanish mackerel.

THE FOOD OF THE ADULT SHAD.

The mouth of the adult shad, as is well known, is practically toothless, and in the throat there are no functionally active teeth, as in the larvæ, so that the latter, in reality, have a relatively much better developed dentary system than their parents. The adult, moreover, prob-

ably feeds in the same way as the generality of the Clupeoids, that is to say, by swimming along with the mouth held open, as I have frequently observed is the habit of the menhaden in its native element. In this way the water which passes through the branchial filter is deprived of the small animals which are too large to pass through its meshes and be swallowed.

It is a common remark of the fisherman that it is seldom that one finds food in the stomach of the adult shad in fresh water; indeed, from personal observation, it is rare or exceptional. The writer has heard many fishermen express their belief, based on this singular fact, that this fish did not feed at all in fresh water during the spawning season. With this unreasonable opinion I cannot coincide, and I have no doubt but that the shad feeds in fresh water, as well as in the sea, upon such small animals as are liable to be captured by its prehensile apparatus. To show that it does probably capture large numbers of small crustacea in fresh water, the following observation will show: A spawning female, captured about twenty miles from Washington, down the Potomac, when the stomach was opened, was found to contain about a tablespoonful of Copepoda, apparently a *Cyclops*, and very similar to the common fresh-water species. This is the only instance in which I found a large amount of food which appeared to have been recently captured, since the carapaces and joints of the antennae and body were still hanging together, with the soft parts partially intact, showing that they had probably been recently swallowed and but partially digested. Upon examining the intestine, however, I invariably found the remains of Copepoda imbedded in the intestinal mucus, the most conspicuous and constant evidence of which was the presence of the hard chitinous jaws of these creatures. This was the invariable rule even where there was no food discernible in the stomach. Besides the remains of Copepoda observed, there were almost invariably present in the intestine green cells, apparently of algous origin; occasionally there were also seen the remains of large crustaceans, possibly shrimps or amphipods, but these were so mutilated and disorganized that the evidence of their presence is founded only upon the occurrence of single joints or fragments. The tests of rotifers and the shells of diatoms of both discoidal and naviculoid forms were also observed.

Upon the foregoing facts the writer bases his conclusion that the shad does feed in fresh water.

If it were of any advantage, we might speculate upon the relations subsisting between the smaller and larger aquatic and marine forms of life, but perhaps enough has been said to show that there is an extensive basis of fact to support what is implied by the title of this paper. The manifold adaptations and contrivances by which food is obtained by organisms which prey upon others, and how the tendency to accumulate the vast amount of the "physical basis of life," represented by the existing Protozoa and Protophytes is practically realized by the

hordes of Entomostraca and other small animals with which both fresh and salt waters teem; how these again are accumulated in appreciable quantities so as to furnish an important source of food is shown by the immense numbers, amounting to many thousands, which may be taken from the stomach of a single fish. In the case where the large quantity of Copepoda was obtained from the stomach there were probably more than 100,000 individuals of these crustaceans, which would average a fifteenth of an inch long and a fiftieth of an inch wide. This fact will serve to show how fine the meshes of the branchial sieve must be to prevent the prey of the shad from escaping from this remarkable collecting apparatus. The soft parts, too, of the individual crustaceans were so well preserved that one could distinguish the pigment of the eyes, the muscles, and intestine with its contents, while the vast number of their eggs mixed amongst their bodies testified to the multitudes of females which had been swallowed. These facts would appear to indicate most positively that the fish had captured its food quite recently and after it had reached quite fresh water.

FISHING AND FISH-CULTURE IN FLORIDA.

By F. B. FISHER.

[Letter to Prof. S. F. Baird.]

Mr. Way turned over your letter to me as I am in the fish business and am in favor of raising fish and stocking rivers. Florida has the finest lakes and rivers for this purpose. This country is filling up with first-class people, who will appreciate this kind of work. I have fished on this river for ten years, and I have fished on all rivers in the United States and coast. Ripe roe shad can be had at this place from five hundred to one thousand every twenty-four hours, if we have an early season. There are small streams of clear water which are cold branches that would answer spendidly for hatching purposes. When I first came here I could pick up shad all along the lake shores where the alligators run them out. The people have been shooting the alligators; thousands have been killed this season, and this gives the fish a better chance. The garfish and catfish are very destructive to all other kinds of large fish and small. Trout or bass destroyed large quantities of small shad, and my object is to destroy catfish and garfish and by making guano of them. Gizzard shad, or mud shad, are not good except for guano. I am in favor of catching fish as long as they can be put to a good use; I don't believe in wasting good fish. I have spent hours stripping shad while fishing here. This is my home, and I will be at your service at any time in stocking these lakes or rivers. Any information I can give in regard to fish, I will be pleased to communicate.

SANFORD, FLA., *September* 12, 1881.

CHANGES IN THE FISHERIES OF THE GREAT LAKES DURING THE DECADE, 1870-1880.

By CHAS. W. SMILEY.

A somewhat wide-spread impression exists in the lake region that the fisheries of the Great Lakes are decreasing. That the number of pounds of fish annually caught is less than formerly is not true, and yet this instinctive impression is doubtless correct if formulated differently. That the resources are diminishing and liable to fail us is true.

From the statements of Mr. J. W. Milner, who visited the fisheries in 1871, and whose report was published by the United States Fish Commission, and by comparison with the investigation made in 1879 by Mr. Ludwig Kumlein under the auspices of the Fish Commission and Tenth Census, the following facts appear:

I. The total number of pounds of fish obtained from the Great Lakes in 1879 was equal to or greater than the yield of any years in the first part of the decade.

II. The apparatus for capture has increased in effectiveness enormously, probably 500 per cent. The increased effectiveness was produced by the introduction of finer meshes in nets, the addition of steam-tugs, the increase of pounds, and very great increase in the number of gill-nets in use. The number of fishermen also increased.

III. The average size of the whitefish and trout taken greatly diminished during the decade.

IV. A considerable number of valuable fishing places became seriously or wholly exhausted. New places were sought out and the supply thus kept up.

V. From these few facts the following conclusion is drawn: The perfection which the apparatus has attained, the diminution in the size of the fish taken, the exhaustion of numerous localities, and the fact that fishing is pressed under these circumstances enough to keep up the maximum supply, indicate that, in the natural order of events, remarkable diminution if not complete collapse is to be anticipated in the coming decade.

VI. The natural order of events may be averted by regulation of the size of meshes, preventing the pollution of the waters, and by artificial propagation.

In support of the foregoing statements the following details are submitted:

I. *The supply maintained.*—In his report for 1872 Mr. Milner gave a table of "the number of pounds of lake fish received by first handlers," but he stated that his figures for Sandusky, Milwaukee, Green Bay, and Mackinaw were incomplete. He then adds: "The sum total of this incomplete record is 32,250,000 pounds of fish." Mr. Kumlein's figures

for 1879 foot up 68,742,000 pounds. That the total supply was not very much larger in 1879 than in 1872 is the universal opinion. It is also likely that the completion of the figures for 1872 would make a total of at least 50,000,000 pounds. In this period, the trade of Buffalo, Milwaukee, and some other places fell off, but was compensated by the increase of trade in Chicago. This decline at Buffalo from 1872 to 1879 Mr. Kumlein places at from 6,374,100 pounds to 4,001,000 pounds. It is impossible to state the exact decline at Milwaukee, but one house reports a decrease from 14,000 half-barrels to 2,058 half-barrels; another house sold 8,000 half-barrels in 1871, 7,000 in 1872, and but 1,908 in 1879. A third firm handled 6,623 half-barrels in 1872, and 10,397 in 1873, but only 2,003 half-barrels in 1879. The only other wholesale dealer gave no comparative figures.

	Pounds.
In 1872 Mr. Milner put the transactions in Chicago at	7,461,102
In 1875 the total is given by a Chicago firm at	11,500,000
In 1876 the total is given by this same firm at	12,240,000
In 1877 the total is given by this same firm at	14,000,000
In 1879 Mr. Kumlein put the Chicago trade at	17,247,570

II. *Maximum effectiveness of fishing.*—The summaries of apparatus used in Lake Michigan as given by Mr. Milner in 1872 and by Mr. Kumlein in 1879 compare as follows:

	For 1871.	For 1879.
Pound-nets	281	476
Gill-nets	450	24,599
Sail-vessels and boats	689	612
Steam-tugs	4	30

In their report the Wisconsin commissioners say: "The number an variety of nets used for fishing are appalling, and their destruction character, supplemented by the spear, is rapidly exterminating the whitefish and salmon, trout in Lake Michigan, Green Bay, and in many of the larger inland lakes."

In 1860 Mr. Kalmbach, who at present is a dealer in Green Bay, began fishing with the pound-net in Bay de Noquet; pound-nets were at that time a new institution in these waters, and in fact his was one of the first trials. He employed two pound-nets, one 18, the other 20 feet deep and 25 by 30 feet square. From the 10th of October to the 25th of November he took from these nets and salted 1,750 half-barrels, or 175,000 pounds, of No. 1 white fish, and could he have secured assistance, salt, packages, &c., he could have more than doubled this amount. Very few fish were smaller than No. 1. Of late years the pound-nets have contained smaller and smaller meshes.

The Wisconsin commissioners, in their report for 1874, state: "At Racine there are four boats in constant use putting out and taking up not less than twenty-five miles of gill-nets. We are told by Mr. Jacob Schenkenbarger, one of our oldest and most intelligent fishermen, that with an

equal number of nets only one-fourth as many fish are caught now as were taken four years ago. He further says: 'Late in October in 1870 I took with a set of thirty nets, at one time, 1,980 pounds of dressed trout. Four years ago it was common to take from 1,000 to 1,500 pounds of fish at each trip. Now we never go over 500, and not unfrequently go less than 200 pounds. The lake is filled with nets and the fish can hardly escape.'"

In the report of 1875 the Wisconsin commissioners say: "At Milwaukee there are four steam smacks and two sailing smacks engaged in fishing. These six smacks have a total of sixty-five miles of nets. Each steam-smack costs about $7,000. The capital invested at that place is not far from $75,000. Kenosha employs four smacks, with about thirty miles of nets, and the catch is about equal to Racine. In these places, Kenosha, Racine, and Milwaukee, there is a total of one hundred and twenty-five miles of gill-nets used. There is a total of nets used in the waters of Lake Michigan to extend from one end of the lake to the other. During the year 1875 there has been great complaint of scarcity of fish, and there has been a falling off of at least one-fourth; so that it is evident to all that the waters of Lake Michigan are being gradually depleted of fish."

III. *Size of fish diminished.*—In their report for 1875 the Wisconsin commissioners say: "In former days the fishermen used nets of a larger mesh and took whitefish that weighed from 8 to 14 pounds each, the latter figures being the largest known to have been caught. Now they have to use smaller-meshed nets and take smaller fish, the larger ones being almost unknown now."

From Green Bay, Mr. Kumlein reported, "Of late years pound nets with small meshes have been largely employed, and thereby millions of young whitefish have been destroyed."

Writing from Port Clinton, Mr. Kumlein says: "In Mr. Nickels' opinion the mesh is now rarely one-half the size it was ten years ago. The fishermen and dealers generally pronounce the decrease, especially of whitefish, very great indeed. However, Mr. Mathews, of Port Clinton, thinks there are just as many whitefish as ever, and as many caught; but, being distributed among more fishermen, they individually take less than formerly. Collectively, the catch is pretty much the same as it was ten years ago, or ever was, in his opinion."

From Menominee, Wis., Mr. Kumlein writes: "The number of whitefish to a half-barrel is yearly growing greater. Sixty has been thought a good number; now ninety is common. I am informed by Capt. Thos. Larsen, of Menominee, that he has seen a half-barrel filled with twelve no longer ago than 1874. It is the opinion of fishermen north of Menominee that the whitefish increased in numbers on their shore till 1876, when the yield rapidly fell off till the present date; it is estimated to have fallen off two-thirds since 1875."

At Washington Island, in 1878, there were over 5,000 barrels, equal to fully 7,500,000, young whitefish thrown away, being too small for market.

Writing from Green Bay, Wis., Mr. L. Kumlein says: "During the autumn of 1878 and the spring of 1879 a prominent dealer at this point collected from fishermen along the shore of the bay large quantities of whitefish, which he purchased already packed and salted in half-barrels; they were bought for No. 1 fish, but in repacking he found some of the packages to contain as many as 600 fish, and of course none were large enough for No. 1. There were a very few No. 2, and the lot was even barely salable as No. 3. Many were found that did not measure 3 inches dressed."

IV. *Depletion and search for new fisheries.*—Of the eastern shore of Green Bay, Mr. Kumlein says: "The once famous fisheries of 'the door' around Washington and Saint Martin's Islands, Little Sturgeon Bay, and Chambers Island are no more. On the grounds where once forty staunch mackinaws and five steam tugs with about 4,000 gill-nets brought to their owners in the neighborhood of $100,000 a year, the fishing is now carried on by a few superannuated Indians and the gulls. The same grounds that in 1873 yielded $4,000 in four months from two pound nets (Chambers Island), this year have yielded not quite $400 worth, and that with nets twice as large. The fishing grounds about 'the door' were to the north and west of Washington Island and south and west of Saint Martin's, extending out in either direction for eight miles and between the two islands the whole distance. These grounds were probably the greatest whitefish spawning grounds in existence prior to 1868. Now they are nearly abandoned, both by fish and fishermen. From May 1 to August 15, 1873, Mr. Blakefield, now of the firm of Blakefield & Minor, of Fish Creek, sold of fresh fish, from two small pound nets set off Chambers Island, $4,175.91 worth. This year on the same grounds, with nets double the size, and in twice the length of time, the product has been a trifle less than $400. On the same grounds, where one boat with two men sold from their gill-nets $9,000 worth of fish in one year, there is no fishing at all now."

Mr. Windross, of Green Bay, estimates that at Oak Orchard and Pensaukee the catch of whitefish has fallen of 90 per cent. since 1869. He lays the decrease, in a great measure, to the sawdust polluting the spawning beds, and in corroboration of his statement cites the following, which he himself has witnessed: In 1845, the whitefish came up the Oconto River as far as the falls, 20 miles, to spawn. With a small seine he took 1,200 half-barrels and could have taken a great many more if he could have used them. This was only at one locality, and they entered all the weirs in the same manner. Now the river bottoms are one mass of sawdust, and it also extends far out into the bay so that the sheltered shoals are so covered that the fish desert them. Sawdust bottom extends out two miles from shore about the mouth of the rivers. Mr. Windross thinks the whitefish spawn more around the island and on the east shore; very few spawning on the shore from Suamico to Peshtigo Point.

Of the tributaries of Green Bay near Menominee Mr. Kumlein writes: "From fifteen to thirty years ago the most profitable fishing grounds were in the Menominee River near its mouth. Here racks were constructed which caught the fish as they came down from spawning. On such racks as high as 600 barrels of whitefish have been taken in one autumn on a single rack."

Mr. Eveland says that not a whitefish has been caught in the river for the past twelve years. As soon as the sawdust began polluting the river the whitefish abandoned it. It was no unusual occurrence to take 600 barrels of whitefish in a season twenty years ago, on one of the Menominee River racks.

"Duluth, Minn., does not seem to have been much of a fishing point until recently. Now the industry is assuming much greater proportions than in 1879. The town itself is only a few years old."—(Statement of Ludwig Kumlein, June, 1880.)

Of Bayfield, Wis., Mr. Kumlein says: "The total number of men employed in 1879 was 130. In 1880 there were over 200. Pounds have been fished here for about twelve years. We could not learn that the decrease had been at all alarming. Ashland Bay (Chequamegan Bay) seems to have suffered the most, it is thought because pound nets have been set there the longest. When a certain locality begins to show signs of giving out, a new one is found, and a rest of a few years is said in some cases to have restored the depleted waters. The present year (1880) the fishing is said to be better than ever before, but it must be remembered that the facilities for capture are better, the men more experienced, and the grounds better known. There is also more twine in use than ever before."

August 30, 1880, Messrs. W. W. Paddock & Co., of Ashland, Wis., who own over 1,200 gill-nets, 23 pound-nets, and 7 seines, write: "There seems to be only one-third of the whitefish caught near Ashland that there formerly was."

Of the fisheries of Lake Superior from Keweenaw Point to Huron Bay, where the catch in 1879 was 8,000 barrels, mostly whitefish and trout, Mr. Kumlein writes: "Whitefish are said to have decreased considerably in fifteen years, especially in Keweenaw Bay."

Mr. Kumlein, writing from Marquette of the fisheries extending 30 miles east and west of that place, says: "Fifteen to twenty years ago the fishing was done almost entirely with hooks for trout and only with gill nets for whitefish. Pounds were not used till 1869. There is supposed to have been a gradual decrease, especially among the whitefish and trout. This is stoutly denied by some, who say the fish have merely moved to grounds inaccessible to the fishermen, or not yet discovered by them."

Mr. Kumlein says of Whitefish Point: "This fishery was purchased in 1870 by Jones & Trevalle, of Buffalo, New York, who employ a steamtug, 2 Mackinaw boats, 2 pound-nets, 2 seines, and 36 box gill-nets. Of late the fishing has not been so profitable as it was five or six years

ago. In 1879 there were but 350 half-barrels salted, while in 1874 there were 2,300. They take only whitefish and trout. In the last three years the catch has been too poor to pay expenses."

West coast of Lake Michigan.—Mr. Kirtland, of Jacksonport, Door County, says that in his neighborhood the amount of whitefish has fallen off fully one-third in seven years. No fresh fish at all is sold here now, as it was three years ago, but it is all salted and disposed of to coasters.

Mr. Marion, of Oostburgh, says that as many fish were caught the last three years as usual, but the number of nets have greatly increased, so that the decrease of each man's catch is thought by some to be fully one-half in 10 years.

At Pentwater, once such a famous ground, there are at present but two boats. In 1874 there were five; 10 years ago, seven; and good fishing; now it is an almost abandoned locality.

Concerning the Mackinaw fisheries, the figures are quite reliable. In 1874, Judge G. C. Ketchum ascertained the product of that year to be equal to 3,542,840 pounds fresh, and in 1879 Mr. Kumlein shows the product to be equal to 3,259,896 pounds fresh, or a decrease of 282,944 pounds, or 8 per cent., in five years.

The other lakes.—While visiting Lake Huron, Mr. Kumlein wrote: "It is estimated by Mr. Case that 10 years ago with the same number of nets now used, three times the amount of fish would have been caught. He used to put up 1,200 barrels in a year. Now he seldom gets over 30 tons."

Writing from Erie, Pa., Mr. Kumlein says: "Many years ago Barcelona was the most important fishing point on Lake Erie, but at the present time it amounts to but little. Dunkirk was also for a long time famous, but very little is done there now. Erie, on the other hand, is improving."

In 1872 Mr. Milner wrote of Sodus Point: "There are three boats here fishing pound nets." In 1879, Mr. Kumlein says, "Now there are none."

In 1872 Mr. Milner said: "Poultneyville, N. Y., has been a resort for Canadian fishermen for years. Fourteen or fifteen years ago they came over in numbers, and they came almost every year." In 1879 Mr. Kumlein said, "Now there are none at all."

From Sacket's Harbor, Mr. Kumlein writes: "Clark & Robbins, of Sacket's Harbor, say, that in 1879 they salted 2,447 half-barrels ciscoes, while in 1879 they got only 100. They think such fish as pike, black bass, trout, &c., have increased since the alewives came, and that the whitefish and ciscoes have greatly decreased."

From Lorain County, Ohio, Mr. Kumlein writes: "The general impression seems to be that the decrease among the whitefish for ten years has been very great. Ten years ago there were not more than half as many nets as now, yet a much greater quantity of fish was taken."

Speaking of the vicinity of Green Bay Mr. Kumlein says: "Five years ago Chambers Island supported nine pound nets, doing a good business. Now there are but two, and those did not pay expenses the last year. In 1873, Mr. Minor alone sold to two firms, one in Chicago and one in Buffalo, $19,571.95 worth of salt fish, and $700 worth of fresh fish. At the same time a Cleveland firm on Washington Island did more than double this business. At the present time none at all are shipped from these same grounds which once yielded such a revenue. Prior to 1873, the average shipments per week from May to July was 700 half-barrels, worth on an average $4. About 1874 the greatest decline was appreciable, and then the fishing suddenly dropped off entirely."

"From 1870 to 1873 between 60 and 100 tons were shipped from Fish Creek, and all taken within a radius of ten miles. These were worth four cents a pound to the fishermen on the ice."

V. *The crisis.*—If the facts heretofore presented establish the allegation that (1) the number of pounds of fish caught has been maintained, but (2) by enormously increased and effective facilities, (3) that large fish are seldom caught and that the small ones have not been allowed to survive, so that (4) already many fishing places have entirely failed up, it cannot be denied that a crisis has been reached such as seriously to alarm all who are interested in these lake fisheries.

VI. *The remedy.*—The great efficiency of apparatus which has been reached will remain. We do not retrograde. Men will still use the powerful appliances which they have discovered. But it is possible for the neighboring States to regulate by law the size of the mesh and some other minor details. This some of the States have attempted, and no doubt others will imitate them. It is also greatly in the interest of certain localities to prevent the pollution of their waters with sawdust, decayed lumber, offal, &c.

Artificial propagation has already been attempted on a limited scale and the methods pretty well worked out. It is believed that if carried on extensively it may become a very powerful factor in the remedy desired.

EXTRAORDINARY FLOODS IN THE POTOMAC RIVER.

By GEO. R. MARQUETTE.

[Extract from letter to Prof. S. F. Baird.]

To the best of my knowledge the heights of rivers at this point in the flood of 1870 were 28 feet 6 inches above low-water mark; this was on the 30th day of September. In the flood of 1877 the greatest height was 29 feet 9 inches above low-water mark: this was on the 25th day of November. This flood was the highest ever known in this town.

HARPER'S FERRY, W. VA.,
January, 17, 1882.

COD AND HALIBUT FISHERIES NEAR THE SHUMAGIN ISLANDS.*

By DR. KRAUSE.

[From "Deutsche Geographische Blätter," Vol. IV, part 4, Bremen, 1881, pp. 267–269.]

You may imagine how greatly we regretted the fact that we could not spend the whole of July in *Behring Strait*, as we thereby lost a great deal, especially with regard to botany and ornithology. All we could do during this part of our voyage hardly compensated us for this loss, although an opportunity was offered to make many interesting observations. Several times, when the vessel was becalmed near the coast, we employed our leisure in cod-fishing. The most favorable result we obtained in the neighborhood of the *Unimak Passage*, where on the 25th July, we caught 80 codfish—related to or identical with the European *Gadus morrhua* (*Kabljau*), *Gadus macrocephalus* Til.—and 3 halibut (*heilbutten*). The delicate flesh of these fish offered a welcome variety in the monotony of our daily fare of salt meat. The captain, however, did not appear to be altogether satisfied with the result of our fishing; as last year he had, while becalmed in the *Unimak Passage*, caught several hundred codfish, which not only supplied his entire crew with fresh meat for ten days, but which also enabled him to salt down several barrels full of fish for future use. The largest halibut caught by him weighed 30 pounds; but occasionally some are caught weighing 300 pounds and more. The codfish as a general rule exceed in size our "*Kabljau.*" The weight of a medium sized cod (after the intestines have been removed) is about 9 pounds. The best fishing grounds are in the neighborhood of the *Shumagin Islands*, where many thousands of fish are annualy caught on a sand-bank about 10 miles from the coast. Three firms in San Francisco send for this purpose small vessels, of about 120 tons, both to the *Shumagin Islands* and to the *Sea of Ochotsk*.† Last year a vessel was also sent to *Sitka*, principally to fish for halibut, and reported very good fishing grounds near that place.

The full cargo of a vessel of 120 tons is 75,000 fish, which are packed in boxes weighing 30 pounds each. This cargo is generally made up in three months. About 12 fishermen are exclusively occupied in fishing, whilst 5 boys tend to the cleaning and salting, for which they receive *monthly* wages. The fishermen do not receive fixed wages, but $25 for every thousand fish. The captain of the vessel, who has to keep an account of the number of fish brought in by the fishermen, is paid by a

* "*Kabljau und Heilbuttenfang bei den Schumagin Inseln*"—[translated from the German by HERMAN JACOBSON].

† Compare M. LINDEMAN: "*Die See fischereien,*" supplement to No. 60 of "*Petermann's Mittheilungen,*" pp. 59 & 60, and M. LINDEMAN: "*Amtliche Berichte über die Berliner Fischerei-Ausstellung*" (Official Report on the Berlin Fishery Exposition), II, "*See fischerei,*" p. 184.

certain share of the total yield, generally $9 to $10 per thousand fish. The boats of the fishermen, 14 feet long and 3¾ feet broad, can, in favorable weather, carry about 320 fish each. By sudden storms the fisherman risks the loss of his whole cargo, as the only way to save himself is to allow the boat to upset and drop the entire cargo in the water. The light boat will of itself again stand upright.

A skilled fisherman can catch 1,000 fish a day. He stands erect in his little boat, on both sides of which he casts a line furnished with a lead and with two hooks. If fish are very plentiful, he is kept busy all the time, hauling in alternately the right and left line, taking the fish off the hooks, stunning them either by a blow on the head or by violently throwing them against a piece of wood, and baiting his hook afresh. The lines, which have the thickness of a quill, are invariably let down to the bottom, and thereupon hauled in 1 fathom. As, from our vessel, we fished at a depth of 50 to 70 fathoms, the hauling in of the lines was no easy work, especially if we take into consideration that we were not properly equipped for this kind of work. In order to protect their hands, the fishermen use so-called "nippers"—rings made of good wool, which are drawn over the hand, and secure the lines merely by friction.

For want of better bait, we used pieces of salt bacon; as soon, however, as a fish had been caught, portions of it were cut out and used as bait The fishermen prefer to use as bait the fresh red flesh of the salmon, or the glaring white flesh of the cuttle-fish, which is said to attract the cod more than any other bait. Even pieces of fish taken from the stomach of a cuttle-fish did excellent service as bait.

The average value of a pound of salt cod in San Francisco (fresh cod is not brought into the market there) is 10 cents. We did not allow the opportunity to pass of enjoying some good fishing. It is true that our drag-net apparatus was not well suited to great depths, but we nevertheless succeeded in bringing up from the bottom considerable booty, the floating net moreover supplying us with a good many objects of interest from the surface-water, particularly in the line of Medusæ.

A PROPOSED POND FOR REARING STRIPED BASS (ROCCUS LINEATUS) IN DELAWARE BAY.

By E. R. NORNY.

[From a letter to Prof. S. F. Baird.]

I send you by mail an eel-skin, not on account of its size, but on account of its color. The lower part, or tail part, was a shiny black when alive, shading to a dull black towards the head, and a dark lead color on the belly. We caught two of these in December after other eels had buried; the other one was a fourth larger than this one. All eels that we have ever seen here have been either green or pale yellow on the back and white on the belly. Is this a distinct species or a sea variety?

I am sorry that you do not feel justified in making the appropriation of about $250 to complete the pond I wrote about a year ago for the propagation of the striped bass in Delaware Bay.

I think my experiment last spring fully showed the feasibility of doing it. Having had a large female in captivity for 14 days, in which time it had nearly finished spawning, and that under very unfavorable circumstances, as it had no fresh water in the pond in all that time, and for the last three days the water was very warm.

I think if it is not attended to this spring the opportunity will be lost here. My fishermen have not made any money fishing for these fish the last three years, and this season will not fish as large a seine as usual expecting to fish pound-nets, in part, which will not be likely to take these large fish. After the bass fishing they expect to go into the sturgeon fishing, which has become very important here.

This pond is embanked on three sides, and next the bay is open, but it requires an extra tide to put water in the pond. It covers an area of over one-half acre; portions of it are from 4 to 6 feet deep, and other portions shoal. We now use it for getting ice. It should be deepened in the shoal places and have a trunk leading to the bay to admit fresh water every high tide and keep a uniform depth. It would also, on portions of the bay front, require a dry stone wall to keep the fish from escaping at extra high tides. I don't think the whole expenditure would be over $250, and if we were to put in from 30 to 40 fish, male and female, they would be sufficient to hatch many millions of young fry. And I think the hatching could all be done between the 25th of April and 20th of May. There would be plenty of time to get it ready in March, after we are done with it for ice, as we are able to drain the water from it when we wish to do so.

ODESSA, DEL., *January* 9, 1882.

SHAD FISHERIES OF THE SUSQUEHANNA RIVER FIFTY-SIX YEARS AGO.

By H. WILLIS.

[From a letter to Prof. S. F. Baird.]

A brief account of the shad fisheries of the Susquehanna River fifty-six years ago may be somewhat interesting, as you have charge of so large a government enterprise in fish-culture.

In the spring of 1827 Thomas Stump owned and operated the largest shad fishery in the United States, immediately below the railroad bridge on the opposite side from Havre de Grace. At the mouth of the river his seine was laid across the river and down for miles along the shore below the village of Havre de Grace. A violent wind commenced, which put a stop for four days and nights to any further action with the seine,

the wind blowing constantly down the river, and no shad could get past the seine. The wind at one o'clock on the fourth night changed and blew directly up the river, and by daylight the outer end of the seine had reached the windlass, one and a half miles from the railroad bridge. At eight o'clock one hundred wagons and carts that had congregated from Lancaster and Chester Counties were loading shad at $4 per hundred. Herring, rock, and other fish, were thrown in without charge. Mr. Stump sent word for miles around in Cecil County to farmers to get herring to manure their lands. It took three and one-half days to get the seine inshore; hundreds of wagon and cart loads of fish were put on lands as fertilizers from that one haul. Shad are not caught at this shore at the present. Mr. John Stump now lives on the property, and, perhaps, can give a more detailed history of that wonderful catch of fish. If my memory serves me right, Mr. Stump, computing the wagon and cart-loads, made the amount, in round numbers, 15,000,000 caught at that one haul. At that time nearly every family put down one to three hundred shad annually in Chester, Lancaster, York, and Dauphin Counties before dams were made. Shad were caught 200 miles up the Susquehanna River, and if proper fishways were made and government would establish hatcheries on this river, and put a heavy fine on all fish-baskets, during the fall, when young shad return to the ocean, millions more shad might be taken, and every family have the benefit of fresh and salt shad, even as they did half a century ago.

Permit me to show what I think of the profits of shad culture:

1,000 shad from the hatchery put into the river cannot cost over $5. Suppose 33 per cent. return, then 333 shad, at 20 cents, each, would be	$66 60
Add four years' interest on $5, at 6 per cent	6 20
The net profit would be	60 40

Even if only one-fourth returned, the benefit to the masses may become incalculable in the way of food. All animals produced on land require vast outlays, while the production of fish is a mere moiety. Nature provides the element and food for fish without cost, and when man will truly see his interest and comfort and give his influence in behalf of the production of fish by artificial culture, which was wholly unknown in our country forty years ago, he will, as in thousands of other cases, wonder why the discovery of fish production was not known at an earlier period.

142 A STREET, N. E., *Washington, D. C.*

After sealing my letter I found I had omitted any allusion to the planting of fish in Michigan. So far as I can judge our State will soon be amply supplied with whitefish, eels, salmon, speckled trout, grayling, and carp. Most of our inland lakes have outlets to the various rivers. I believe the carp will become our standard fish, as we have

thousands of shallow lakes and streams that this fish may do well in, while such fish as bass, pickerel, perch, and flesh-eating fish seek deeper and colder waters. Whitefish are caught varying in size from 3 to 6 pounds in lakes where they were planted four years ago. When bass and pickerel shall be got out carp and whitefish will become our standard fish. Eels, I think, will inhabit all our waters. I have opened hundreds of eels in Pennsylvania, but never found a fish in one of them or in a catfish, as I have in bass, pickerel, perch, and some other kinds. Hence fish that live on vegetable matter are the kind for us to propagate. I hope to see fish culture encouraged by national and State bounties. Michigan will ere long have fish to export to other States if properly encouraged.

NOTES ON THE GLOUCESTER FISHERY.

By S. J. MARTIN.

[Letter to Prof. S. F. Baird.]

The most of the netters have put their nets ashore. Could not get fish enough in them to make it pay. The fishermen that put their nets down in November have used them up. No fault with the nets. They don't get any fish, because there are no fish inshore. I think if one of the boats had gone out to Long Island it would have done well. There have been plenty of fish at Coney Island and Rockaway this winter. I think some nets would have done first-rate. They fish there with handlines, two men in a boat. They don't fish more than three miles from shore. There are plenty of herring this winter at Grand Manan and Newfoundland. Some vessels have made three trips this winter to Grand Manan, five vessels at Newfoundland, coming home full. Two have arrived with full cargoes. Herring are selling at 75 cents a hundred. The vessels are doing well on George's. The vessels get more halibut this winter than they have the past ten years. They fish on the eastern part of the bank in 40 fathoms water. They get as high as 8,000 pounds. In catching 20,000 pounds cod, that makes a good trip. There are six vessels getting ready to go to the western bank after codfish. It is early for vessels to go the western bank. What started them off so early? The haddock vessels (one of them was on the western part of western bank) found plenty of codfish; more cod than haddock. All kinds of fish bring a high price. Fresh halibut sold yesterday at 7 cents a pound; fresh cod, 3 cents a pound; haddock, 3½ cents a pound; salt cod out of the vessel, 3¼ cents a pound. Dried George's cod sold yesterday at $5 75 a quintal. Everything looks prosperous for the coming year. The most of the old stock is out of the market.

GLOUCESTER, MASS., *January* 22, 1882.

COD-FISHING WITH GILL-NETS IN IPSWICH BAY, MASSACHUSETTS.

By S. J. MARTIN.

[Letter to Prof. S. F. Baird.]

I had a letter from Mr. Clark saying that Major Ferguson wanted to know if he could get some cod spawn. I don't think we can get any this winter. The reason is, that there are no hand-line fishermen. All the fish are now caught with nets and trawls, which are set over night and hauled in the morning. There is therefore no chance to get spawn from live fish.

The fish are scarce. The prospect in Ipswich Bay is better for net-fishing than it was last month. Boat Eva May caught 7,000 pounds in two nights with twenty-four nets. That is better. The boats that put their nets ashore have taken them on board again. They are going to try their luck again. They don't catch any fish on trawls. They find nets better in the winter than trawls.

Seventy thousand pounds of cod have been caught in nets during the past fortnight. This is more than they caught inshore on all the trawls they had set.

GLOUCESTER, MASS., *February* 1, 1882.

ARTIFICIAL CULTURE OF MEDICINAL LEECHES AND OF SPECIES OF HELIX.

By RUDOLPH HESSELL.

[Letter to Prof. S. F. Baird.]

Referring to your formerly expressed intention to make at the United States fish ponds a trial of breeding the *Hirudo medicinalis*, or medicinal leech, and other species of *Hirudo*, I beg to remind you of the matter, deeming this season most favorable for the importation of a number of propagative animals. It will require for the first trial not more than 200 to 300 or 400 individuals and I have found a little pond about 36 inches by 16 inches the best size.

I recommend for this purpose the green species, *Hirudo officinalis*, from Southeastern Europe (Hungary, Croatia, Bosnia), and the brown species, *Hirudo medicinalis*, from Southwestern Europe (Italy, Spain, France, and some few parts of Southern Germany). There are some other different kinds coming from Asia Minor, Egypt, Algeria, and Morocco; but I think the above named are the best for breeding and medical purposes. They have more eggs in the cocoon (12 or 15 to 20) and are not subject to many diseases, and they are hardy enough for our climate. I must explain to you that the so-called marketable *Hirudo* that we find in the drug-stores is *not the propagative one;* it is too small,

too young for this purpose. It requires a larger size—four to six year old ones, of 4 inches to 5 inches in length. I kept in my ponds as breeders a large size, 5 inches to 6 inches long and 1 inch thick (after feeding). They call them in Austria, Germany, "mother-leeches;" in France, *sang-sue-vaches.*

On this occasion I believe it my duty to call your attention to the special breeding of another animal, which is extensively carried on in Italy, Spain, France, Austria, and South Germany, namely, that of *Helix pomatia.* This breeding is as yet quite unknown in America, although large quantities of *Helix aspersa* are brought to New York from private establishments each winter.

How extensively the breeding of helices is carried on in Southern Europe, France, Austria, Italy, and South Germany (not at all in Central and Northern Germany), you may gather from the circumstance that Marseilles ships more than 10,000 to 15,000 hundredweight for Paris and London; Genoa the same quantity.

Austria breeds a great many; Bavaria, Würtemberg, and Baden, too, for the Vienna, Munich, Swiss, and Paris markets.

When a young boy I collected them by the thousand in the valleys and little hills of the Black Forest Mountains and in the sunny meadows of the Upper Rhine, where I found many other kinds of *Helix.*

I myself raised some of them years after, by the thousand, in my own business, and these were the *Helix pomatia* out of the vineyards, *Helix rhodostoma* from France and Italy; *H. aspersa* (France) and *H. vermicularis.*

Not much room is needed to keep about 1,000 or 2,000 living in, and, for breeding purposes, a box, 20 feet by 5 feet by 2 feet in depth, sunk into the ground and covered with a wire screen frame, will answer to raise about 40,000 to 50,000, with a few square yards of ground to plant the food for them.

WASHINGTON, D. C., *February* 9, 1882.

FISHERY NEWS FROM GLOUCESTER, MASSACHUSETTS.

By S. J. MARTIN.

[From a letter to Prof. S. F. Baird.]

The weather during the last month has been very bad for all kinds of fishing. When there is a chance they get some fish in nets. When nets have been down two or three days with fish in them, most of the fish are spoiled. The nets get badly torn; they could do better with them than with trawls, however, if they had fine weather. The schooner Northern Eagle arrived yesterday; she had been trawling down at Boone Island. When there was a chance to set, they would get 2,000 pounds of fish with 9,000 hooks. The average a night with 24 nets last week was 2,500 pounds. The nets would do better than that. We had such

bad weather that it keeps the water thick and dirty all the time. When the nets are hauled up they are full of sea-weed, kelp, and all such stuff; so, in rough weather, they don't have much chance to fish. I had a talk with George, my son; he says he never saw so many beach-fish as he saw last Wednesday: they were off shore and as far in as the eye could see; they were bound to the westward. The same day he saw a large school of porpoises bound west. The vessels that were out in the last gale, February 4, come in slowly. I am sorry to say I think some of them will never come. Some of the haddock vessels have been gone four weeks. Some of the George's vessels have been out as long; I hope they will all come, but I think it doubtful. All the vessels that have come in are more or less damaged; they all report the gale very hard. I think if we had fine weather they would do well with nets for a month to come. The fresh-halibut catchers that have come in fared hard; their decks swept, and the dories stove. All say one thing: it was a bad time.

GLOUCESTER, MASS., *February* 12, 1882.

AN OPINION REGARDING THE INFLUENCE UPON THE COAST FISHERIES OF THE STEAMERS USED IN THE MENHADEN FISHERY.

By J. W. HAWKINS.

[Letter to Prof. Spencer F. Baird.]

JAMESPORT, N. Y., *January* 20, 1882.

I am engaged in the menhaden fishery, having been master of a steamer in that business for six years past and before that for four years in a sail vessel.

In view of the fact that a bill is pending before the New Jersey legislature to stop the use of steamers for catching menhaden off the coast of that State, will you please state your views as to the relative extent of the injury, if any, done to the fisheries for edible fish by the operations of the menhaden fishermen as compared with the influence of other causes, including the destruction of menhaden by their natural enemies?

1. Do we catch edible fish ourselves with our set-nets?

We do not find them with the menhaden, except as they are chasing and worrying the menhaden.

We never look for nor set for anything else but menhaden, and, take the season through, we do not catch enough to supply our table on board the steamer.

There was one instance that you have heard of, but it was exceptional and was the only one that ever happened in my experience. In June last, while on my steamer, the J. W. Hawkins, off Rockaway, I set for what I supposed to be a school of menhaden. When I had surrounded them I thought I discovered they were bluefish and that my seine was gone (for bluefish eat a seine, and such a school would have destroyed

it quickly), but I could not get away from them, and was glad to find they were weakfish. I took about 20 tons of them and carried them at once to Fulton Market, New York, and sold them for edible fish. At the same time two other steamers made hauls of the same and sold theirs in the same way.

I have been engaged in menhaden fishing for thirteen years and for six years have been master of a steamer in that business, and in my judgment, during that time, not one fish of one thousand of those which have been rendered into fertilizers was an edible fish, unless the menhaden themselves are called such.

2. Assuming that menhaden are the chief food of the bluefish, and in part of the weakfish, bonito, cod, and bass, do our steamers render those edible fish scarce by driving off or catching up the menhaden?

That is a question which every one engaged in the business is interested in asking.

I am entirely satisfied with the position taken by Professors Baird, Huxley, Goode, and others, that all the menhaden that man has ever caught in any one year have been but as a drop in the bucket compared to those which are annually destroyed by the bluefish and sharks, and their other natural enemies.

Some years, when with a sail-gear, I have found less fish than in other years, but since I have been in a steamer, my cruising has been more extended and I can't say that I have seen less fish in any one year than in another. During the season of 1881 I cruised from Cape Henlopen to Montauk Point, and in my judgment as many fish came on to coast in the spring as I ever saw in a spring before, and although the fish were in different localities from what they sometimes are, I think I saw as many menhaden that season as ever before.

2. Does the cruising of our steamers drive the menhaden from any part of the coast? I believe it does not.

Although it is true that menhaden do oftentimes seem to be shy, and do not show up as well as at others, and although you may by rowing ahead of or around a small school cause them to sink below the surface, and that they will then change their position before showing up again, and although when you make a stab at one side of a school it may turn just far enough to clear your seine and then pursue its course; yet it is my opinion, and so far as I know it is the universal opinion of fishermen, that when a large body of fish is coming upon the coast, or is located upon the coast, or at sea, there is no such thing as stopping them or varying their course by nets or boats or steamers or by any other means that we know of.

We cannot explain the movements of the menhaden.

During most of the season of 1881 they were on the coast of New Jersey, and most of the fishing fleet were there, but the menhaden did not leave. It is said that edible fish were scarce on the coast during 1881, but it

could not have been from the absence of their food, for the menhaden were there.

Steamers certainly don't frighten the fish. Their going over a school of menhaden has no more effect than a sail vessel. They sink at the bow and come up at the stern. Moreover the steamers don't go near the school; they simply carry the fishing-crews to the fishing-grounds and wait off one side to receive the fish after they are caught.

NOTES ON THE GLOUCESTER FISHERIES.

By S. J. MARTIN.

[From a letter to Prof. S. F. Baird.]

Five boats are fishing for cod with nets, each boat having 24 nets. They have a new set of nets. The rest of the vessels that had nets are using trawls. They have done better with nets the last week. The five boats with nets landed at Rockport last week 44,000 pounds of large cod. Some of the trawlers got as many fish. They were mixed fish—cod, haddock, hake, cusk—so the trawlers did not get half the money the netters did. The fish they got in nets are large, mostly male fish. I looked at 800 pounds and found that two-thirds were male fish. The female fish had very little spawn in them. I found 6 females with spawn nearly ripe. I was glad to hear that you got plenty of cod spawn at New York. Cod have been plenty off the Long Island coast all winter. I will tell you a little about haddock fishing on George's. There has been a large school of haddock on George's for the last three weeks. I will give you some facts, then you can judge for yourself. Schooner Martha C. arrived yesterday with 90,000 pounds, gone eight days; schooner Josie M. Calderwood, 85,000 pounds, gone seven days; schooner H. A. Duncan, 80,000 pounds, gone seven days. Four vessels left here Saturday and were back Wednesday with 40,000 pounds of haddock, having fished one day and a half. That is good work and quick work. The vessels don't find the codfish very plenty on George's. The average pounds of fish brought in by the George's vessels the last trip were 16,000 pounds of cod and 2,000 pounds of halibut. Most of them were gone three weeks. The halibut-catchers have done nothing. Schooner Corrina H. Bishop arrived yesterday; been out 6 weeks; lost 6 men and 1,500 pounds of halibut. Two of the haddock fleet are missing; I don't think they will ever come back; they have been out since the 18th day of January. The vessels are schooner Edith M. Pew, Captain Corliss; schooner Paul Revere, Captain Bently. They have not been seen since the gale of February 4. The price of fresh fish the last week has been high; there was a large pile of haddock yesterday. They all sold at 2 cents to 3½ cents a pound—good prices since there are so many fish.

GLOUCESTER, MASS., *February* 19, 1882.

ON THE FOOD OF YOUNG WHITEFISH (COREGONUS).

By S. A. FORBES.

[Letter to Prof. S. F. Baird.]

Please allow me to add to the facts relating to the first food of the whitefish, detailed in my letter of last spring, the following notes from recent observations:

According to an arrangement made with Mr. Frank N. Clarke, I went to Racine, Wis., on the 16th instant, in order to search the lake for minute animal life at the place where it was proposed to plant a lot of young whitefish. Mr. Clarke's party made better railroad connections than he expected when he telegraphed me, and the fish had been released about nine hours when I arrived. I took a boat as soon as possible, and made a careful search for entomostraca in the water of Racine River, near its mouth, and in the lake at various depths and distances from the shore.

The entomostraca occurring were all of species which I had previously collected off Chicago and in Grand Traverse Bay, viz, an undescribed cyclops (*C. Thomasi*, MSS.), an undescribed variety of *Diaptomus gracilis* Sars; a new species of centropages (especially interesting, since the genus has been hitherto unknown only from salt water); and *Daphne galeata?* Sars.

The cyclops and diaptomus were about equally abundant, but the centropages and daphnia were much less common. All were much more abundant in the rivers than in the lake, and in the latter were more numerous at or near the bottom than at the surface. This was perhaps owing to the cool and lowering weather. Immense numbers of diatoms lined the towing net after every haul, with a brownish, mucilaginous coating, the vegetable life far surpassing the animal in quantity.

I dragged the towing net as nearly as possible a quarter of a mile at each haul, and saved each time the entire contents of the net. Taking a definite part of the product of the most fruitful haul and counting the entomostraca in this, I reached the conclusion that they occurred here at the rate of two or three to the cubic foot of water, or, taking favorable and unfavorable situations together, at about one or two to the foot; this suggests the propriety of scattering the deposit of fish as much as possible, unless it is certain that they scatter rapidly when left to themselves. It should be noted that the most abundant species here at this season of the year were, fortunately, the smallest. Mr. Clarke kindly gave me a few young fishes left in one of the cans, and I succeeded in getting about twenty-five of them home alive.

I put these in a small aquarium with well-water on the 17th and supplied them with entomostraca and algæ of various kinds from the pools

of this vacinity. The entomostraca were chiefly large cladocera (*Simocephalas*), cyclops, and canthocamptus. To the algæ, the little fishes have paid no attention whatever, although they are well scattered through the water. They have followed the smaller entomostraca around with growing interest from the first, occasionally making irresolute efforts to capture them, but did not actually begin eating until today. Now, however, more than one-half of them have evidently taken food. In the seven cases examined, this consisted entirely of cyclops and canthocamptus, the smallest entomostaca in the water. The cladocera are evidently too large for them, and they even seem afraid of them, although, of course, the former could do them no harm.

The fishes all have visible remains of the egg within the body, but, as their teeth are already well developed, they are doubtless at the proper age to commence eating. This seems to me nearly conclusive proof, taken with my previous observations, that the first natural food of the whitefish is small entomostraca, especially cyclops (*Canthocamptus* occurs rarely, if at all, in Lake Michigan), but it may be worth while to repeat my little experiment on a larger scale and under more natural conditions.

I have consequently taken steps to study a number of specimens kept in the water of the lake and supplied with the organisms occurring in the lake waters.

It will be impossible for me to keep alive the few which I have long enough to tell how well they would flourish on the food supplied to them.

ILLINOIS STATE LABORATORY OF NATURAL HISTORY,
Normal, Ill., February 20, 1882.

SOME RESULTS OF THE ARTIFICIAL PROPAGATION OF MAINE AND CALIFORNIA SALMON IN NEW ENGLAND AND CANADA, RECORDED IN THE YEARS 1879 AND 1880.

[Compiled by the United States Fish Commissioner.]

NEW BEDFORD, MASS., *May* 20, 1879.

Prof. S. F. BAIRD:

SIR: I have just been in the fish market and a crew were bringing in their fish from one of the "traps." A noticeable and peculiar feature of the fishery this year is the great numbers of young salmon caught, especially at the Vineyard, although some few are caught daily at *Sconticut* Neck (mouth of our river). There are apparently two different ages of them. Mostly about 2 pounds in weight (about as long as a large mackerel) and about one-half as many weighing from 6 to 8 pounds; occasionally one larger. One last week weighed 23 pounds and one 18 pounds. The fishermen think they are the young of those with which some of our rivers have been stocked, as nothing of the kind has occurred in past years at all like this.

JOHN H. THOMSON.

NEW BEDFORD, MASS., *June* 1, 1879.

Prof. SPENCER F. BAIRD:

SIR: I received yours. I have examined carefully since your letter, but no salmon have been taken. The run was about the two first weeks in May and a few the last of April. Mr. Bassett had about 30 to 35 from the trap at Menimpsha, and 10 or 12 from Sconticut Neck, mouth of our river. Mr. Bartlett, at his fish market, had about one dozen; 12 from the traps near the mouth of Slocum's River, six miles west of here, and I have heard of two taken at mouth of Westport River. As to the particular species, I do not get any reliable information, as so few of our fishermen know anything about salmon, and in fact the men from the traps on Sconticut Neck did not know what the fish were.

JOHN H. THOMSON.

FISHING ITEMS.

The squid fishery from this port has thus far proved a failure. There have been five arrivals with but a few barrels. Schooner Crest of the Wave is high-line, she having succeeded in obtaining fifty barrels.

A ten-pound salmon and seventeen tautog, weighing over one hundred pounds, were taken from the weirs of Magnolia, Thursday night. This is the first salmon caught off Cape Ann for over thirty years. On Saturday morning three more large salmon were taken and 150 large mackerel. The fishermen are highly elated at the prospect of salmon catching.—(Cape Ann Advertiser, June 6, 1879.)

[Postscript to a letter from Monroe A. Green, New York State Fishery Commission, to Fred Mather, June 9, 1879.]

"P. S.—Kennebec salmon caught to-day in the Hudson River at Bath near Albany weighing twelve and a half pounds, sold for 40 cents per pound. The first that have been caught for years."

STATE OF MAINE, DEPARTMENT OF FISHERIES,
Bangor, August 25, 1879.

[Extracts.]

DEAR PROFESSOR: * * * We have had a great run of salmon this year, and consisting largely of fish planted by us in the Penobscot four or five years ago, so far as we could judge; there were a very large number, running from 9 to 12 pounds. The east and west branches of the Penobscot report a great many fish in the river. On the Matta wamkeag, where we put in 250,000 and upwards, in 1875 and 1876, a great many salmon are reported trying to get over the lower dam at

Gordon's Falls, 13 feet high. These fish were put in at Bancroft, Eaton, and Kingman, on the European and North American Railroad. The dam at Kingham is 13 feet; at Slewgundy, 14 feet; at Gordon's Falls, 13 feet, and yet a salmon has been hooked on a trout fly at Bancroft, and salmon are seen in the river at Kingman, and between the dams at Slewgundy and Gordon's Falls. * * * The dealers in our city have retailed this season 50 tons Penobscot salmon, and about 3 tons Saint John salmon; it all sells as Penobscot salmon. Saint John salmon costs here, duty and all included, about 14 cents per pound. Our first salmon sells at $1 per pound, and so on down to 12½ cents the last of the season. Salmon at Bucksport has sold to dealers here at 8 cents. Two tons taken at Bucksport and Orland in 24 hours. Average price at retail here for whole season, 25 cents.

Truly, yours,

E. M. STILWELL.

STATE OF MAINE, DEPARTMENT OF FISHERIES,
Bangor, October 4, 1879.

DEAR PROFESSOR: My delay in replying to your kind letter has been from no want of courtesy, but a desire to send you the required "data" you asked. Neither myself nor Mr. Atkins have been able to procure them. The weir fishermen keep no records at all, and it is difficult to obtain from them anything reliable; while the fishermen above tide water are a bad set of confirmed poachers, whose only occupation is hunting and fishing both in and out of season. They are always jealous and loth to let us know how good a thing they make of it, for fear of us and fear of competition from their own class. Four or five years since I put in some 300,000 salmon fry into the Mattawamkeag at Bancroft, Eaton, Kingsmore, and at Mattawamkeag village. There are three dams between Mattawamkeag and Bancroft—none less than 12 feet high. About six weeks since Mr. Nathaniel Sweat, a railroad conductor on the European and North American Railroad, while fishing for trout from a pier above the railroad bridge at Bancroft, hooked a large salmon and lost his line and flies. Salmon in great numbers have been continually jumping below the first dam, which is called "Gordon's Falls." My colleague, Everett Smith, of Portland, a civil engineer, while making a survey for a fishway, counted 15 salmon jumping in 30 minutes. A Mr. Bailey, who is foreman of the repair shop at Mattawamkeag, walked up to the falls some three weeks since entirely out of curiosity excited by the rumors of the sight, and counted 60 salmon jumping in about an hour, within half or three-quarters of a mile of the falls. This is on the Mattawamkeag, which is a great tributary of the Penobscot. On the east branch of the Penobscot there has been a great run of salmon. An explorer on the Wassattaquoik reported the pools literally black with salmon. A party of poachers, hearing the rumor, went in from the town of Hodgon and killed 25. I inclose you

a letter to me from Mr. Prentiss, one of our most wealthy and prominent merchants, which speaks for itself. I will be obliged to you if you will return this, as I shall have occasion to use it in my report. On the west branch of the Penobscot I hear reports of large numbers of salmon, but the breaking of the two great dams at Chesancook and the North Twin Dam, which holds back the great magazine of water of the great tributary lakes which feed the Penobscot, which is used to drive the logs cut in the winter, through the summer's drought, has let up all the fish which hitherto were held back until the opening of the gates to let the logs through. These fish would not, of course, be seen, as they would silently make their way up. I regret that I have nothing of more value to give you. Hoping that this small contribution may at least cheer you as it has me,

I remain, truly, yours,

E. M. STILWELL,
Commissioner of Fisheries for State of Maine.

Prof. SPENCER F. BAIRD,
United States Commissioner Fish and Fisheries.

BANGOR, *October* 3, 1879.

E. M. STILWELL, Esq.,

DEAR SIR: Prof. C. E. Hamlin, of Harvard, and I made a trip to Mount Katahdin last month for scientific examination and survey of the mountain. I had been salmon fishing in July on the Grand Bonaventure, on Bay of Chaleur, and I could not see why we could not catch salmon on the east branch of the Penobscot at the Hunt place where we crossed it on our way in to Katahdin. I thought the pool from mouth of Wassatiquoik to the Hunt place, about a half-mile, must be an excellent salmon pool, and my guide and the people there confirmed this opinion. They said over a hundred salmon had been taken in that one pool this season. The nearest settlement, and only one on the whole east branch, is about six miles out from there, and the young men go on Sundays and fish with drift-nets. No regular fishing for market—only a backwoods local supply can be used. These fish were all about of one size—say 8 to 11 pounds. There were never enough fish there before to make it worth while for them to drift for them. A few years ago no salmon were caught there at all. Twenty-two years ago, before our fish laws were enacted, the farmer at the Hunt place used to have a net that went entirely across the river clear to the bottom, which he kept all the time stretched across, and he only used to get two or three salmon a week. I was there August, 1857, with Mr. Joseph Carr, an old salmon fisher, and we fished for ten days and could not get a rise. The net had been taken up, because the farmer did not get fish enough to pay for looking after it. But the stocking the river makes it good fishing, and I intend to try the east branch next season with the fly.

Very truly,

HENRY M. PRENTISS.

EAST WINDSOR HILL, CONN., *October* 13, 1879.

Professor BAIRD:

DEAR SIR: It may be of interest to you to know that your salmon are not all lost. Last Friday, 10th, I was with a party of three fishing in Snipsic Lake, and one of our party caught a salmon that weighed 1¾ pounds. This is the second one taken since the pond was stocked, as I was told. The other was caught this summer and weighed 12 ounces.

Cannot something be done to save our fish in Connecticut River? There is an establishment at Holyoke, Mass., and another at Windsor Locks, Conn., that are manufacturing logs into paper, and I am told that the chemicals used for that purpose are let off into the river twice a day, and that the fish for half a mile come up as though they had been cockled. Both of these factories are at the foot of falls where the fish collect and stop in great numbers and are all killed. Our shores and sand-bars are literally lined with dead fish. Three salmon have been found among them within two miles of my office. They were judged to weigh 12, 20, and 25 pounds. The dead fish are so numerous that eagles are here after them. I have received nine that have been shot here in the past two seasons.

I have written you in order that the fish commissioners might stop this nuisance and save the fish that they have taken so much pains to propagate.

Truly, yours,

WM. WOOD.

May 29 to June 13, 1879.—W. Scott Lord, Esq., gives the following weights of 51 Salar salmon caught in the Restigouche River near the junction with the Matapediac:

1 of 4 pounds.
1 of 10 pounds.
2 of 11 pounds.
2 of 12½ pounds.
1 of 13 pounds.
1 of 14½ pounds
2 of 15 pounds.
1 of 15½ pounds.
1 of 16 pounds.
1 of 17½ pounds.
1 of 20½ pounds.
2 of 23 pounds.
5 of 24 pounds.
1 of 24½ pounds.
1 of 24¾ pounds.
6 of 25 pounds.
3 of 25½ pounds.
8 of 26 pounds.
4 of 27 pounds.
1 of 29½ pounds.
2 of 33 pounds.
1 of 34 pounds.
1 of 36½ pounds.
1 of 38½ pounds.
1 of 40½ pounds.

51 weighing 1,200¼ pounds.

SAINT STEPHEN, *March* 1, 1880.

Prof. SPENCER F. BAIRD,

U. S. Commissioner Fish and Fisheries:

DEAR SIR: I send you remarks in relation to the Restigouche and Saint Croix Rivers, which, though crude, I am sure are quite correct, as they are either taken from the official statistics, or are facts of which I am myself cognizant. You may, if of use, publish any part of them. I very much wish we could procure some young shad for the Saint Croix; this fish was once very abundant, and perhaps would be again if introduced. I know you have been very successful in restocking the Connecticut. Our old people deplore the loss of the shad—say it was a much better food-fish than the salmon. I do a great deal of shooting, and am much interested in ornithology, and specimens of our birds that you might want I should be happy to lookout for; do a good deal of coast shooting winters; have been hopefully looking for a *Labrador duck* for a number of seasons—fear they have totally disappeared.

I have nice spring-water conducted to my house and think of doing a little fish-hatching in a small way. The amount of water I can spare is a stream of about half-inch diameter; the force will be considerable, as the water rises to top of my house, some 50 feet above where I should set trays. I write to you to ask what hatching apparatus would be best to get, where to buy, and probable cost. I am trying to get some sea-trout ova to hatch in it. I presume all your California ova have been disposed of ere this.

FRANK TODD.

SAINT STEPHEN, *March* 1, 1880.

Prof. SPENCER F. BAIRD,

U. S. Commissioner Fish and Fisheries:

SIR: In regard to the Saint Croix, would say, that it was once one of the most prolific salmon rivers in New Brunswick, but owing to the erection of impassable dams, fifteen or twenty years ago, this valuable fish had almost entirely disappeared. At about this time fishways were placed in all the dams, and gradully salmon began to increase, but the first great stimulus was given some ten years ago by the distribution of some hundreds of thousands of young salmon in the headwaters, by the fishery commissioners of Maine. The Dobsis Club also placed in the Saint Croix some 200,000 or more from their hatchery, a portion being the California salmon. With these exceptions our river has had no artificial aid, but for the last five years the number of salmon has largely increased, due mainly, no doubt, to the deposits before mentioned. The fish ways are generally in good condition (although some improvements will be made), and fish have easy access to headwaters, That large numbers go up and spawn is evidenced by the large numbers of smolt seen at the head of tidal water in the spring, many being taken by boys with the rod. I have reason to expect that our government will hereafter

distribute annually in the Saint Croix a goodly number of young salmon, which, together with the contributions of the Maine commissioners, will soon make this fish again abundant. Alewives are very abundant, and apparently increasing every year. Shad that were once plenty have entirely disappeared. I very much wish that the river could be restocked with this valuable fish; possibly you could kindly assist us in this. Landlocked salmon (here so called) are, I think, *nearly* or quite as plenty at Grand Lake Stream as they were ten years ago; this, I think, is almost entirely due to the hatchery under the charge of Mr. Atkins; the tannery at the head of the stream having entirely destroyed their natural spawning beds, the deposit of hair and other refuse being in some places inches deep. The twenty-five per cent. of all fish hatched, which are honestly returned to our river, is, I think, each year *more* than we would get by the natural process, under *present* circumstances, in ten years.

FRANK TODD.

SAINT STEPHEN, N. B., DOMINION OF CANADA.

Prof. SPENCER F. BAIRD,

U. S. Commissioner Fish and Fisheries:

SIR: I think it has been clearly demonstrated in this Dominion that, by artificial propagation and a fair amount of protection, all natural salmon rivers may be kept thoroughly stocked with this fish, and rivers that have been depleted, through any cause, brought back to their former excellence.

I would instance the river Restigouche in support of the above statement.

This river, which empties into the Bay of Chaleur, is now, and always has been, the foremost salmon river in New Brunswick, both as to size and number of fish. It has not a dam or obstruction to the free passage of fish from its mouth to its source, yet up to 1868 and 1869 the numbers of salmon had constantly decreased. This, no doubt, was occasioned by excessive netting at the mouth, and spearing the fish during the summer in the pools; natural production was not able to keep pace with this waste. In the year 1868 the number of salmon was so small that the total catch by anglers was only 20 salmon, and the commercial yield only 37,000 pounds.

At about this date, the first salmon hatchery of the Dominion was built upon this river and a better system of protection inaugurated; every year since some hundreds of thousands of young salmon have been hatched and placed in these waters, and the result has been, that in 1878 one angler alone (out of hundreds that were fishing the river) in sixteen days killed by his own rod eighty salmon, seventy-five of which averaged over twenty-six pounds each; while at the same time the numbers that were being taken by the net fishermen below, for commercial purposes, were beyond precedent, amounting in that one division alone

(not counting local and home consumption) to the enormous weight of 500,000 pounds, and the cash receipts for salmon in Restigouche County that year amounted to more than $40,000, besides which some $5,000 was expended by anglers; this result was almost entirely brought about by artificial propagation. A new hatchery of size sufficient to produce five million young fish annually will no doubt soon be erected by the Dominion Government upon this river.

A somewhat similar record might be given of the river Saguenay. Some years ago anglers and net fishers of this river said it was useless to lease from the department, as the scarcity of salmon was such as not to warrant the outlay. A hatchery was built, and this state of things is now wonderfully changed; so much so, indeed, that in 1878 salmon, from the great numbers which were taken at the tidal fisheries, became a drug in the market, selling often as low as three cents per pound, and angling in the tributaries was most excellent.

Some one hundred million young salmon have been artificially hatched and distributed in the waters of the Dominion during the last few years, and new government hatcheries are constantly being erected.

Yours, &c.,

FRANK TODD,
Fishery Overseer, Saint Croix District.

FOOD OF THE SHAD OF THE ATLANTIC COAST OF THE UNITED STATES (ALOSA PRÆSTABILIS DE KAY); AND THE FUNCTIONS OF THE PYLORIC CŒCA.*

By E. R. MORDECAI, M. D.

1. The small size and the arrangement of the teeth would suggest that the food of this fish is easy of prehension.†

2. The gullet is capacious.

3. The stomach, as is well known, consists of a conical, and gizzard portion. The tissues of the former do not differ from those of the stomach of an ordinary fish. The latter is a powerful muscular apparatus, terminating in a very constricted pyloric orifice.

4. The pylorus opens into an intestinal tube neither remarkable for its length nor breadth.

5. The pyloric cœca are fusiform sacculi, varying in number, by my enumeration, from sixty to a hundred—according to the development of the fish.

They enter the intestinal canal. The points of communication are marked by depressions in the mucous membrane of the wall of the viscus. Sometimes six or eight cœca will be found to open into a single depression.

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* Reprinted from a pamphlet entitled: Food | of the | shad of the Atlantic coast | of the | United States, | (Alosa præstabilis De Kay); | and the | functions of the pyloric cœca. | by | E. R. Mordecai, M. D., | Member of the Academy of Natural Sciences of Philadelphia. | — | Philadelphia: | King & Baird, Printers, 607 Sansom St. | 1860.

†The teeth are very minute.

Below the pylorus the intestine is expanded for an inch and a quarter of its length. It is into the inferior wall of this *basin* that the largest, longest, and the greatest number of these appendages enter.

The cœca vary in length, by actual measurement, from an inch to three inches and a half; and in circumference, from that of a small probe to that of a number six catheter. When the fish is in good condition, they are separated from each other, and supported by delicate layers of fat; the cellular tissue of which is abundantly supplied with vessels, that expend themselves on the walls of the cœca. The blind extremities of the sacculi gravitate freely in the abdominal cavity.

Such, in part, is a rapid anatomical sketch of the organs of digestion. What is the food of the fish? and what are the functions of the cœca?

As the shad of the Western Atlantic makes its appearance first off the coast of Georgia, it occurred to me that could specimens, *fresh-run* from the sea, be obtained from this locality immediately after the appearance of the fish, that an opportunity would be offered of discovering from the contents of the stomach more in relation to its habits than was known.

On the 2d of February of the current year, two shad, which were fortunately procured from Savannah, Ga., were examined at my office in Mobile.

The stomach of the first contained nothing except a small quantity of brownish mucus, which others have described.

But I was astonished to find the cœca greatly elongated and distended. They were of a flesh color—evidently due to their contents, viz: a homogeneous-looking fluid, which, when squeezed through the cœcal orifices into the intestinal canal, was found not to differ materially, under the naked eye, from the brownish mucus alluded to above. To my mind the functions of the cœca were apparent.

The gizzard-stomach of the second specimen, in addition to the brownish mucus, contained a minute quantity of solid matter. This was immediately mounted on a slide and subjected to a lens of low power suitable for examining vegetable tissue entire.

I was amazed at the beauty and perfection of the objects displayed—minute cylindrical stalks, and differently shaped and colored fragments of algæ, gemmed with the pearly calcareous shields of infusoria! Many of the shells, having altogether escaped the effects of the action of the stomach, preserved their integrity—bi-convex loricæ predominating.

A Bailey would know and name them at a glance.

They are to be seen of all sizes, from the fully formed disc to that presenting under the same power a mere point.

An algologist might readily determine the species to which the fuci belong.

The question relative to the food of *Alosa præstabilis* is answered.

Shad feed and fatten on marine fuci, and on the microscopic organisms that are parasitically attached. Both are necessary to the economy of the fish. How beautiful the adaptation! The succulent vegetable mat-

ter, held and macerated in the conical division of the stomach, passes gradually into the gizzard, where it is in time thoroughly disintegrated by the powerful walls of this muscular apparatus, aided by the sharp points and edges of the broken shells of the infusoria. Reduced to chyme—the brownish mucus of some observers—it passes the small pyloric orifice, is changed by admixture with the proper secretions, which meet it at the threshold, and is immediately *sucked* up into the cœca, that distend to receive it.

In these receptacles the liquid food, prepared in the ocean, is stored away to nourish the fish in its long passage, five or six hundred miles perhaps, to the headwaters of rivers, where the ova are to be deposited and receive impregnation. Thus we may explain how it is that a fish coming to us in superb condition from the sea, with nothing apparently in its intestinal canal but a little discolored mucus, can make this ascent, execute the functions necessary for the reproduction of its species, and descend to its feeding grounds in the deep.

In the absence of food the fish feeds on the nutritive contents of the cœca; either by forcing a certain quantity of the fluid into the large intestine, or, and this is far more likely, by absorption immediately from the cœca—each of these appendages being provided with a sphincter, or valvular arrangement, to prevent the involuntary passage of its contents into the general reservoir. The action of gravity on the free extremities of the loaded tubes would materially assist this retention.

Something like this, there is little doubt in my mind, takes place in the other species, and genera, provided with cœca, that run from the sea to spawn. These useful appendages varying in number, and size, according to the *habits* of the fish, and the presence or absence of food in the fresh-water streams which they ascend.

Some finding, although precariously, appropriate food, a part of the fortuitous excess of to-day is stored away for to-morrow's scarcity.

The adult shad from *its* habits during the season for spawning (for the fatness of the fish and the apparent emptiness of its alimentary canal have long been subjects of wonder) requiring an abundant supply of food for *long* voyages, has a great number of receptacles.

The number varies in individuals of the same species; less than seventy and more than ninety-five having been carefully counted by me in the specimens examined. And this difference seems to be directly in proportion to the size, and, there is good reason to believe, the age of the fish. It may be thus explained. In the young adult shad some of the cœca are rudimentary.* They are gradually developed with the growth of the fish until a fixed number is reached for the species.

* Since this paper was read before the Academy, I have found some of these organs in a rudimentary state in the young adult of Labrax lineatus (striped bass, rock-fish), and in specimens of the species of Dioplites (another of the perch family) generally known as "trout" at the South.

Preparations proving these ichthyological points are in my possession.

Let us take a British enumeration of these organs in different families, having different habits, and requiring different food. "While there are six in the smelt (*Salmo eperlanus*), there are seventy in the salmon (*S. salar*). In like manner, though there are eighteen in the anchovy (*Clupea encrasicolus*), there are twenty-four in the herring (*C. harengus*), and fourscore in the shad (*C. alosa*). In some, as in the cod, says the same authority, they consist of several large trunks, ramified into numerous small ones.

The herring and anchovy, though closely allied to the shad, are of small size, and do not go far beyond brackish water to spawn. Hence their cœca are few and small. The salmon, a fish of large size, has fewer receptacles than the shad; for the former can obtain, from day to day, suitable food in the fresh waters it frequents. But the adult shad, from the nature of its food, is dependent upon that, in the liquid state, which it brings with it from the ocean; and consequently its pyloric appendages are numerous and long.

In the cod, as was stated before, the cœca consist of several large trunks ramified into numerous small ones. Now, as this is exclusively a salt-water fish, the arrangement here would seem to be at variance with the opinion expressed concerning the uses of these organs. But, compared with the shad, the cod is of enormous size, and, though a salt-water fish, it is highly probable that, for the most part, it migrates from its feeding grounds to perform its reproductive functions in *securer* oceanic localities than those in which it fattens.

It is the shad, however, which occupies our attention.

The distance from shore at which this fish can obtain its appropriate food may be inferred from the botanical nature of the algæ on which they feed; and perhaps the shells of the infusoria may assist the search. As a guide, the statement of Forbes should be regarded.

"The British marine plants," says that author, "are distributed in depth or bathymetrically in a series of zones or regions which extend from high-water mark down to the greatest explored depths" (for plants).

There are no waters more fertile in algæ than those of the Gulf of Mexico; and none in which the minute organisms, that fasten on marine plants, are more numerous and varied. A cold aqueous belt, of vast area—bounded on the south by the gulf-stream—almost isothermal with that which washes the shores of Georgia and the Carolinas—extends along the coast from the mouth of the Mississippi to Cape Sable.

Here may be found several species of alosa. One, from its size and physical construction, and as an article of food, rises considerably above insignificance. It is frequently caught in the headwaters of the rivers of Alabama, where it spawns. But the shad of the Atlantic, a fish affording, from its gregarious and prolific nature, a valuable food for man, does not naturally exist in the Gulf of Mexico. Yet there is much reason

to believe that in this sea it could obtain, in great abundance, the peculiar food adapted to its wants.*

Once successfully introduced, in numbers sufficient to sustain the species against the natural causes of destruction, it must become abundant. For the temperature of the gulf-stream opposing, according to recent experiments, an irremovable barrier to its exit, its oceanic range, on the western side of Florida, would be limited to the body of cold water, the boundaries of which have been described.†

Many of the rivers that pour their contents into this belt would seem to be as well adapted to the functions of reproduction as any the shad naturally frequents. Let us take for comparison the Ockmulgee—one of the branches of the Altamaha, a river of Georgia—and the Flint River, a tributary of the Apalachicola, which flows through western Florida into the Gulf of Mexico.

These streams have their origin in the same State, and spring from a geographical range which is geologically the same. At one point they almost touch. Now the Ockmulgee, like its sister tributary, the Oconee, teems with shad; while in the Flint River they are unknown. Yet they are in juxtaposition, and their waters, for the practical purposes of this deduction, are homogeneous. One makes its way to the Atlantic Ocean, where shad *abound;* the other to the Gulf of Mexico, where they do *not exist.*

But be the possibility of its successful introduction into the Gulf what it may, such, as has been shown, is the food of this fish; and such, with deference to the opinions of others, are the functions of the cœca.

These assertions rest on—

1. The examination of twenty-five or thirty shad obtained from Savannah, Ga, at different times, from February 2d to March 15th, of this year (1860). In three specimens only were the stomachs entirely empty, and in these the cœca were greatly distended.

2. Nineteen stomachs with their contents dried, and glued to glass with Canada balsam. In all of which are to be seen the fuci and shells of infusoria, and in *one* numerous cylindrical stalks of algæ are plainly to be recognized by the naked eye.

3. A part of one of the cœca opened, and flattened out on a slide, the dried contents resting on the mucous membrane. With a glass of higher power, sparkling points of the calcareous discs, which have escaped the action of the gastric juice, may be seen, here and there, in the thinnest parts of this specimen.

4. A parasite from the mucous surface of the above cœcum, identical with one taken from the conical stomach of the *same* fish.

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* Since this pamphlet was printed I have discovered in the stomach of a species of Alosa, very numerous in the Gulf of Mexico, fucus and shells identical with those found in the Atlantic shad.

† See a paper by Mr. Wm. Gessner, of Milledgeville, Ga., in August No. of the Cotton Planter and Soil, p. 256, Montgomery, Ala., 1858.

5. A section of the intestinal canal, cut from a point below the opening of the cœcum nearest the termination of the alimentary tube, spread on glass. It exhibits on its mucous membrane an inspissated matter of a somewhat darker brown color than that of No. 3, and the débris of microscopic shells, small enough to pass the pylorus, but too large to enter the mouths of the cœca.

6. A wet preparation of the gullet, stomach, cœca, and intestine.

7. A preparation in ether of the cœca, their orifices, and the intestinal expansion in which they open.

8. Several dried stomachs (some of the last obtained) unopened, but supposed to contain the fuci and infusoria described.

The most important of the specimens have been placed in the hands of Lieutenant Holt, U. S. A., who has kindly undertaken to deliver them to Dr. Walter F. Atlee, of Philadelphia, to be presented by him, with this monograph, to the Academy of Natural Sciences.

[An abstract of this paper will be found in the December number (1860) of the Proceedings of the Academy of N. Sciences of Philadelphia, *appended* as a continuation of the report from the Biological Department of the Academy for May, 1860. By reference to this report it may be seen that the statements made in relation to the *contents of the stomachs and the cæca* were abundantly verified by members of the Academy in the specimens mounted for microscopical examination which accompanied this paper.*

Before the shells of the minute organisms can be easily recognized, the solid contents of the stomach should be thinly spread on glass and thoroughly dried, in order to remove the liquid matter which renders these small objects obscure. With specimens thus prepared from fish fresh run from the sea during the spawning season, examined under a bright sunlight, the investigations detailed in this paper may be easily repeated.

MOBILE, ALA., *October* 25, 1860.]

THE MICROPYLE OF THE EGG OF THE WHITE PERCH.

By JOHN A. RYDER.

[Letter to Professor S. F. Baird.]

I have found the micropyle of the egg of the white perch; it measures .0075 millimeter or $\frac{1}{3333}$ inch in diameter. Average diameter of egg, $\frac{1}{34}$ inch; of oil sphere, $\frac{1}{100}$ inch.

WASHINGTON, D. C., *May* 17, 1881.

*As the vegetable matter in the stomach of the fish is in a disintegrated state, a lens, generally, is required to determine its nature.

EVELOPMENT OF THE SILVER GAR (BELONE LONGIROSTRIS), WITH OBSERVATIONS ON THE GENESIS OF THE BLOOD IN EMBRYO FISHES, AND A COMPARISON OF FISH OVA WITH THOSE OF OTHER VERTEBRATES.

By JOHN A. RYDER.

The development of the fish we are about to describe is in itself of little practical importance, but because it serves to illustrate in a very remarkable way the manner in which the blood is originated in an embryo teleostean, it may serve to teach us a useful lesson as to the origin of the elements of the blood in other forms, such as the salmon, whitefish, &c., a complete knowledge of which it is desirable that we should possess, in order that we may more fully comprehend the evolution of their structures in the egg. Another matter of peculiar interest is the presence of numerous filaments which are distributed over the whole surface of the very thick egg-membrane, and which are at first tightly coiled around the latter, but which afterwards uncoil, when they twist together into strands, and also become entangled with the filaments arising from other eggs so as to bind large numbers together into large clusters. Not only are large masses of one brood thus joined together, but it is also found that if the recently spawned ova come into contact with slender objects in the sea they immediately wind their filaments about the latter, and are by this means suspended very securely, so that with the ebb and flow of the tides they are constantly bathed by different water. It appears that in this way their incubation would be favored, for after their fixation by the filaments or threads, the ebb and flux of the tide sweeping through and by the clusters of eggs would in effect very closely resemble the conditions to which fish ova are exposed in the process of artificial incubation. It would seem that in this case nature had anticipated the protective designs of man in developing a means by which the survival of a species might be insured. How the filaments have been evolved it appears impossible to the writer to explain; he can think of no rational hypothesis of evolution by which it would be possible to account for their development. While the ova of a comparatively useless fish are thus provided with a means of protection and suspension, not only to favor their incubation, but also to keep them from being overwhelmed with the ooze and mud of the sea-bottom, there are other species of considerable value, the eggs of which are probably provided with similar thread-like appendages. I allude to the so-called "jumping-mullet," *Mugil albula*, a fish much esteemed for the table in some places along our eastern coast. It therefore becomes a matter of some importance to know how many of our native species have their ova provided with filaments for the purpose of attaching them to each other and to foreign objects.

Professor Haeckel appears to have been the first to describe fish ova

with filaments, but he thought the fibers were inside the egg-membrane instead of outside of it, as may be learned by reference to his paper on the subject in *Müller's Archiv* for 1855. Professor Kölliker, in the *Verhandl. d. physik. u. med. Gesellschaft in Würzburg*, eighth volume, for 1858, rectifies Haeckel's observations, and shows that the fibers or filaments are external, but it does not appear that he ever understood their real function, viz, to provide a means of fixation and support while the ova were undergoing incubation. Haeckel unfortunately observed only unripe ova, contrary to what he supposed, as is clearly shown by his figures, but he found the fibers present in the eggs of *Belone*, *Scomberesox*, *Hemirhamphus*, and *Exocœtus*. The writer has observed them in the unripe eggs of *Hemirhamphus unifasciatus*, but has not had any opportunity to observe them in the eggs of the flying-fish, *Exocœtus*. In all of these the fibers are distributed and attached at intervals over the whole surface of the egg, but in the *Atherinidæ*, as shown by my observations on the eggs of *Chirostoma notata* in Mobjack Bay, Virginia, in 1880, there are only four filaments, which are attached to the vitelline membrane at one pole of the egg and quite close together. These are at first coiled around the vitelline membrane in one plane quite closely, as in *Belone*, but they unwind when the eggs are discharged into the water, when the threads of adjacent eggs become entangled so as to form clusters of considerable size. In this genus the filaments are nearly half an inch long, without a swollen base, attached to an egg one-sixteenth of an inch in diameter. We saw that all of the genera of *Scomberesocidæ* were found to have their ova provided with filaments. The genus *Arrhamphus* is the only one the eggs of which have not been observed. It is very probable that all of the genera of *Atherinidæ* have ova with filamentous processes; at any rate it is desirable that they should be looked for in *Atherina*, *Atherinichthys*, *Tetragonurus*, and *Labidesthes*. This supposition also raises the question whether the *Mugilidæ* do not have eggs of the same kind. A confirmation of this hypothesis would be desirable in that the large number of species in the family, their wide distribution and considerable size, conspire to render them of value as food-fishes over a large area of the earth's surface. It is quite as important for us to know what natural means exist to favor the survival of the germs of species as it is for us to know what artificial means to provide for their increase and protection. In fact the latter kind of knowledge ought to be based upon and supplement the former, since it is by a combination of natural and artificial protective agencies that much more can be done to increase the number of food-fishes than by the latter alone. It may indeed happen that we will yet learn that certain species need no protection save that which would prevent their capture during the breeding season.

DEVELOPMENT.

The development of the germinal disk of the silver gar is essentially like that of the Spanish mackerel and the cod. The egg is quite large,

measuring when mature about one-seventh of an inch in diameter. After impregnation the egg does not increase much in size in consequence of the absorption of water from without, as in the case of the eggs of the shad and whitefish. The vitellus, in consequence of this, lies almost in contact with the egg-membrane, as shown in Fig. 1. The egg-membrane is without pore canals, and is therefore not a zona radiata like that of the shad and salmon. It is about $\frac{1}{500}$ of an inch in thickness, which is more than six times that of the zona radiata of the shad egg. The fibers or filaments which arise from the surface of the egg are cylindrical and taper towards their free extremities. The attached end of the fiber is swollen into a truncated cone, which is joined to the surface of the egg-membrane by its base. From the truncated apex of the cone the fiber arises, and a very distinct transverse line indicates the point where the former joins the latter. The fibers may be forcibly pulled off of the membrane; when this is done a slight concave depression remains on the surface of the latter, marking the point of attachment of the conical base of the filament or thread. The thickness of the threads is about the same as that of the egg-membrane, and they are apparently composed of the same material, as indicated by their color and behavior towards reagents. An examination of the ovaries of different females in various stages of maturity reveals the fact that the fibers are tightly coiled about the egg-membrane in the immature condition in the ovarian follicles, and that they are also wound round the globular egg in but one plane, which we may designate as the equatorial plane. This appears to be the tendency of the fibers on the eggs of other Scomberesocoids as well as in *Chirostoma*. After extrusion the fibers on the egg uncoil and stand out, looped and twisted together in all directions, as shown in Fig. 1. The length of the fibers varies, but it does not usually much exceed the diameter of the egg.

The ovary of the silver gar is a very long, simple cylindrical pouch, varying in size and length very greatly, according to the degree of maturity of its contents, which are discharged by way of a wide oviduct opening behind the vent. The ovary when quite mature is sometimes a foot in length and nearly an inch in diameter. As usual in fishes the male is notably smaller than the female, and the milt or spermary is a simple, elongate, somewhat peculiarly lobulated, three-sided organ, extending, like the ovary in the female, for the greater part of the length of the body cavity; it empties its products into the water through a wide sperm duct behind the vent. The genesis of the spermatozoa is effected in much the same way as in the Spanish mackerel, as is shown by sections of the organ in my possession.

As in many other teleostean fishes the germinal protoplasm of the mature egg covers the vitellus as a thin envelope; in the egg of *Belone* it is extremely thin, but there is a great number of very transparent, refringent, minute vesicles scattered through this germinal pellicle, which is of uniform thickness over the whole vitellus. It has occurred to me that

inasmuch as the vesicles in the germinal pellicle disappear when the latter has been aggregated into the germinal disk, may it not be that they represent the fragments of the disintegrated nucleus? This view, however, as already stated in my paper on the Spanish mackerel, is negatived by the results obtained in staining the germinal pellicle of the cod egg, where these vesicles remain untinged. No oil spherules are visible in the vitellus, the latter being optically homogeneous. The whole egg is heavier than the sea-water, and quickly sinks to the bottom; its specific gravity must therefore be much greater than that of the shad or salmon.

The germinal disk is developed in the usual way by the aggregation of the germinal protoplasm of the pellicle, which covers the vitellus at one pole of the latter. It does not appear that impregnation certainly takes place before the formation of the germinal disk. Observations on this point are, however, still too scanty and untrustworthy to be of much value, and until special attention is directed towards this point it will be most commendable to maintain a skeptical silence in regard to the views held on this subject. Special apparatus is needed to conduct researches on the phenomena of impregnation of fish ova, supplemented by reagents which will act quickly, so as to fix the nuclear changes which occur almost instantly. We may then study the conditions presented by different stages in dead preparations which have been properly stained so as to develop the appearance of the nucleus, as little of a trustworthy nature can be learned from any of the twenty species of living eggs which the writer has seen, for in almost all cases the nuclei of living fish eggs are not visible under the microscope, even though magnifying powers of two hundred and fifty diameters be applied. With the use of reagents the matter is much simplified, the nuclei at once become distinct, and their metamorphoses may be very distinctly shown under a power of sixty to seventy-five diameters.

In Fig. 1 the germinal disk three hours and twenty-three minutes after impregnation has been segmented into eight cells; at the end of four hours and forty-five minutes it has been segmented into sixteen cells, as shown in Fig. 2. The disk during this time has not increased in transverse diameter, and is relatively smaller, when compared with the vitellus, than the germinal disk of the salmon. It is very transparent, and is less different from the vitellus in color and optical properties than the disk of any fish egg known to me. It is this feature which makes it hard to find in the live egg, and when found difficult to study, unless the light is skillfully managed so as to bring out the contours of its component cells. The nuclei are still quite invisible in the latter while alive. The stages which immediately follow are still more difficult to study, because as the disk spreads to form the blastoderm it becomes relatively thinner and more inconspicuous than in any other form known to me, so that it is necessary to manipulate the light in the microscope with extreme caution.

By the tenth hour the segmentation of the disk has advanced very much, and the cleavage of the component cells has proceeded so as to have split them up into superimposed layers lying in the plane of the great diameter of the disk, as shown in Fig. 3. Besides the development of superimposed layers of cells by another process, which I do not clearly understand, a portion of the germinal matter of the disk has been segmented off at its margin to form a wreath, *w*, of much depressed cells, which seem to be severed from the edge of the disk proper by a slight interval all the way round. These appear to take an important share in the development of the thick rim of cells *r*, which limits the border of the blastoderm after it has spread out somewhat, as indicated in Figs. 4, 5, and 6. Up to the tenth hour of development the disk has expanded but slightly; it now measures about one twenty-fifth of an inch in transverse diameter, exclusive of the wreath of marginal cells, or about the same as in the stage represented in Fig. 1. In Fig. 3 it is, however, lenticular, convex above and below, and it is only during the next twelve hours that it begins to spread, become of almost uniform thickness, convex above and concave below. The singular changes undergone by the disk of the cod were not so narrowly observed in this species, although they probably occur. What is alluded to is the change from the biscuit-shape of the morula stage, with a thick margin and almost flat upper and lower surfaces, to the lenticular form of Fig. 3, which is viewed somewhat obliquely, to that of the concavo-convex form, which is already assumed somewhat earlier.

With the lateral expansion of the disk, the segmentation cavity *sc* is developed beneath the upper germinal layers, which constitute its roof. Here, as in other forms studied by the writer, this cavity does not disappear, but persists and expands laterally as the growth of the blastoderm proceeds. In *Coregonus albus* the cavity is principally roofed over by the epiblast, which is composed of flattened, juxtaposed cells, while smaller, rounded cells constitute its imperfect floor. The cells of the floor appear to have been budded off from the mesoblast near the edge of the blastoderm. A similar state of affairs probably exists here, for as yet I can find no evidence of a positive character to show that we have in *Belone* an exception to the mode of development generally exhibited by embryo fishes; but this structural feature will be further considered, in relation to the genesis of the blood, at another place.

In Fig. 4 the embryo-swelling, which extends from *e* to the edge of the blastoderm, is still in a very primitive condition. The cells, which are to develop into the body of the embryo, have not yet been arranged into tracts, and little more than the upper or epiblast layer, with the mesoblast lying below the latter, and above the hypoblast, can be said to be differentiated. There is still no indication of a neural or primitive groove; no differentiation of lateral mesoblastic plates, from which the muscular segments or somites are to be differentiated. Whether these are lateral outgrowths, or diverticula from the hypoblast of the primitive

enteron or gut, as the latter is pushed inwards from behind, we are not yet ready to assert, but such a mode of origin appears possible, if not probable. By the end of the first twenty-four hours of development the germinal disk measures almost a line across, as shown in Fig. 4, and the part of it from which the body of the embryo will be developed is the widened portion of the blastodermic rim *r*, just below *e*. The cells composing the disk at this stage are already too small to be successfully represented in figures of the size we have adopted, consequently the blastodermic rim and embryonic portion of it will hereafter be merely more densely dotted.

In Fig. 5 the disk or blastoderm is represented at thirty-one hours and twenty minutes after the commencement of development; it now measures about a tenth of an inch across, but is still extremely thin and has apparently added nothing to its substance by an incorporation of any of the underlying yelk. The blastoderm is here again viewed somewhat obliquely, in consequence of which the rudiment of the embryo *e* appears to have its head end inclined to the right hand. The embryonic rudiment is relatively small, much more so than in other forms in the same stage of development. When the blastoderm is viewed from the edge in the living state, as a transparent object lying at one side of the vitellus, the segmentation cavity *sc* is found to be exceedingly shallow vertically, but its lumen may still be distinguished. The embryo, however, is much more clearly marked than in Fig. 4; it is more prominent and is rapidly growing in length from the rim towards the center of the blastoderm. This brings us to the consideration of the growth in length of the embryo from the edge of the blastoderm. I am inclined to believe that the theory put forward by Balfour (Comparative Embryology, II, 254) must be accepted with considerable qualification, as stated by him in the following language: "The growth in length takes place by a process of intussusception, and, till there are formed the full number of mesoblastic somites, it is effected, as in Chætopods, by the continual addition of fresh somites between the last-formed somite and the hind end of the body." The only apparent exception to this rule is in *Elecate canadus*, where it appears that the segmentation of the mesoblast on either side of the neurala or spinal nervous cord is continued backwards so as to involve the rim of the not yet closed blastoderm, and that the somites of the hind end of the body are formed by the coalescence of the blastodermic rim in the median line continuous anteriorly with the primitive groove. Should this be found to be the constant mode of development in *Elecate*, it will be necessary to accept in part the view urged by His and Rauber. It is to be observed, however, that the segmentation of the rim of the blastoderm in *Elecate* proceeds from before backwards, and that while it extends beyond the posterior extremity of the neural cord and notochord, the unusual segmentation of the rim of the blastoderm behind the proper embryonic body into muscular half segments may be a mere acceleration or hastening of the

usual mode. Such unusual acceleration or retardation in the development of certain structures in various species of teleosts is not unusual, and would be as likely to affect the segmentation of the mesoblastic blastodermic rim into muscular segments as any other part of the embryo. There is another most serious objection to the unqualified acceptation of Balfour's theory of the growth of the embryo from the edge of the blastoderm without further addition from that source. If we do not admit that the blastodermic rim becomes transformed into the body of the embryo, what becomes of it? Nothing can be more certain than that, upon its closure, little or nothing is left of it; it has apparently been incorporated into the embryo's body.

This view appears to be well sustained by what may be observed in the development of *Belone*. Up to the time when the embryo may be said to be fairly outlined as in Fig. 6, forty-three hours and forty minutes after impregnation, the material of the blastoderm and embryo has acquired little or no increase of bulk in consequence of the incorporation of portions of the massive yelk. In Fig. 6 we see that the embryonic body occupies about a quarter of the circumference of the yelk. The blastoderm has grown down over and inclosed more than half the yelk globe, and its rim is contracting at the tail to complete the closure. When this is accomplished, the point where the closure takes place entirely disappears; the edges of the rim have been so perfectly fused together that the point of union, marked at first by a pore behind the end of the tail, with radiating wrinkles running out from it fifty-one hours after development began, as shown in Figs. 8 and 10, has soon after completely vanished. The material of the slowly contracting rim is finally fused into a solid flat plate of cells at the caudal end of the embryo, after the membranes of the latter—epiblast and hypoblast—have inclosed the yelk. The conversion of this caudal plate into the mesoblastic, epiblastic, and hypoblastic structures of the tail end of the embryo accordingly appears to me to be beyond question. But I would not commit myself to an adherence to the doctrine that the embryonic body was formed by a gradual coalescence of the thickened edge of the blastoderm from before backwards along the median line. If the reader will observe Fig. 9 he will see that the annular blastodermic rim *r*, as it approximates the closed condition at the fifty-first hour, is not circular, as in Fig. 5, but decidedly oval. The sides of the oval blastodermic annulus are now approximated more rapidly than the ends, as we see still further exemplified in the oval pore-like openings in Figs. 8 and 10. It is, therefore, probably nearest to the truth to say that the embryo grows in length both by intussusception from behind forwards of the blastodermic rim as well as by the coalescence of the latter, not along the median line, but by a gradual fusion as it is finally closed over the yelk.

The segmentation of the mesoblast proceeds in the usual way in *Belone* from before backwards, as shown in Fig. 6 at *so*, and there is no

reason to suppose that the somatic mesoblast extends much beyond the sides of the body at this stage, but it ends abruptly on either side between the epiblast and splanchnopleure the same as in *Alosa*, as shown by transverse sections. Fig. 6 shows the optic vesicles *o* developing at the head end of the neural or spinal cord, which is solid in this species at this time, as in embryo bony fishes generally. The notochord is also faintly indicated at this stage. The vesicle *k*, the nature of which is so puzzling, shown at the under side of the tail in Figs. 6, 8, 9, and 10, is well developed; it was originally described by Kupffer, and it has been supposed to be primitively joined to the posterior end of the intestine, but of this there is as yet no satisfactory proof. It disappears entirely at a later stage of the evolution of *Belone*, and appears to play only a transient and comparatively inconsequential part in the process of development. The usual lateral flattening of the anterior end of the neural or spinal cord takes place, as shown in Fig. 9, in optic section through it and the optic vesicle on either side. Further stages in the development of the optic vesicles are shown in Figs. 7 and 10, in which the rudiments of the auditory invaginations are also represented. In Fig. 10 the embryonic body only is represented, as in Fig. 9; the mesoblast has been segmented into a greater number of muscular somites, and the point of closure of the blastoderm is shown at the tail, where it forms the caudal plate already alluded to.

DEVELOPMENT OF THE HEART AND BLOOD.

As stated at the beginning of this paper, the genesis of the blood of *Belone* is perhaps the most interesting part of its history. The heart develops in the usual way in the segmentation cavity below the head; at first an annular mass of cells, it soon becomes tubular, and is prolonged forwards until its venous end *a* extends to the front end of the head. An arterial channel is at once developed from its hinder end through the body of the embryo between the notochord and intestine, and just below the tail at *z* it widens into a capacious vessel of very uneven caliber and passes entirely around over the yelk between the epiblast and the hypoblast to again empty its contents into the anterior venous end of the heart at *a*. The vitelline blood-system is at this stage, seventy-two hours after impregnation, as simple as it can possibly be. It is a mere channel which is as yet hardly provided with proper walls, except in the region of the heart and body, running the whole length of the body of the young fish and continued around the yelk back to the heart. On either side of the body of the embryo a small vessel also makes its way outwards from the aortic channel or vessel, but suddenly returns again to empty its fluid contents into the heart at *a*. This vessel, or rather the one on the right side, is shown at *v''* in Fig. 11. With the progress of development the most noteworthy change which takes place in the arrangement of the two vessels on either side of the body is their rapid extension and growth outwards over the yelk, as shown

at v', v'', in Fig. 12, ninety-four and a half hours after development had begun. The blood corpuscles or disks at once begin to be formed, but they do not appear to be uniformly oval at first, but very soon acquire the red color characteristic of this tissue. The corpuscles have a tendency to adhere together in clusters or clumps, and circulate in this way in masses through the blood channels of the embryo, as shown in Fig. 11 at v. The blood channels soon develop communicating branches, and these are formed in a very interesting way, as represented in Fig. 13. Narrow blind prolongations of the hollow vessels are formed at their sides and at each pulsation of the heart these are lengthened; several of them are shown at c, c, c, Fig. 13. Frequently two such blind prolongations meet and join, so that a communication is established between the larger channels. In this way the vascular network is developed over the yelk, as shown in Figs. 14 and 16. In Fig. 14, one hundred and sixteen hours after impregnation, the vitelline vascular system is moderately complex; there are three vascular channels, the right one, v', the left one, v'', and the median one, v, all of which join and pour their contents into the venous end of the heart at a. It may also be observed that where the vessels cross the semi-diameter of the egg at the side and where their cavities are seen in optic section, the epiblast is lifted up to give them passage. Between the vessels at this stage it was possible to observe in optic section here and there at the sides of the vitellus the space between the epiblast and hypoblast, which we have regarded as the remains of the persistent segmentation cavity. The heart space p, which in this as in other cases appears to be derived from the segmentation cavity, becomes progressively more and more spacious in the successive stages represented in Figs. 11, 12, 14, 15, until it attains a most extraordinary development in Fig. 16, one hundred and sixty-five and a half hours after impregnation. In Fig. 11 the heart is tubular and not differentiated into regions; in Fig. 12 the ventricle and venous sinus are beginning to be marked off from each other; in Figs. 14 and 15 the bulbus aortæ may be for the first time distinguished, but in all of these phases the whole organ is dragged forward in the median line far beyond the front of the head. In Fig. 16 the venous end of the heart begins to be inclined downward, but is at the same time very remarkably elongated; the bulbus aortæ *ba* is almost tubular and the ventricle *ve*, almost globular, is held in position to the floor of the heart cavity by a muscular or fibrous band, s. Below the ventricle the greatly elongated tubular venous sinus appears to be fastened by diverging muscular bands to the lower part of the enormous heart space p. The point of attachment of the venous end of the heart in the lower portion of the heart space is the scene of the very remarkable mode of genesis of blood corpuscles of this species. Where the vessels v, v', v'', in Fig. 14, converge, it is already apparent that an active metamorphosis of the yelk substance into blood disks is in progress. The first sign of this has, however, already made its appearance in Fig. 11, where the

blood corpuscles are clearly derived by budding off from the inferior hypoblastic walls of the vitelline blood channels. Clusters of adherent, not fully formed, blood disks are circulating *en masse* through the vessels. Some of them appeared to be amœboid in character. But the process of blood formation is in its most active phase in Figs. 15 and 16, where the vitelline vessels converge to join the heart. Here it was observed that the vitellus was breaking up into clear globular corpuscles from $\frac{1}{1500}$ to $\frac{1}{400}$ of an inch in diameter; the largest corpuscles were always observed to be most deeply imbedded in the yelk, or most remote from the vascular channel. A progressive segmentation of these corpuscles was also observed, from which it was concluded that they were directly concerned in the formation of the nucleated oval blood disks. The rapid formation of blood disks in this region had the effect of piling them up into great adherent masses about the venous end of the heart, which was also more distinctly marked as the red color of the ovoidal corpuscles became developed as hæmoglobin was formed. The pulsation of the heart would for a long time sway these masses of corpuscles back and forth, until finally one after the other would be detached from the mass and carried along in the current of blood. Not only were the corpuscles budded off in this way into the blood channel itself, but they were also found to be held in suspension in great numbers in the great heart space *p*, where every pulsation of the heart would cause them to vibrate in the surrounding serous fluid. At the upper part of the heart chamber great numbers of blood disks were found to be collected together below and in front of the origin of the breast fin *f*. The hypoblastic origin of the blood in this species is therefore undoubtedly a fact, as was learned from repeated observation; whether the hypoblast was more than the intermediary parent of the blood disks I am not in a position to state, but this was probably the case, for as the hypoblastic structures were broken down into corpuscles in the blood-forming region at the venous end of the heart, there appeared to be a constant renewal of germinating cells from below which were clearly derived from the yelk. The actual phenomenon of cleavage of the cells was not observed since the nuclei were relatively indistinct, and their genesis at this point was assumed to be undoubted from the constantly augmenting numbers which were developed independently of any which might accumulate in consequence of eddies in the blood current. The blood disks themselves were not measured, but as compared with the size of the corpuscles from which they were derived they were estimated to measure somewhat less than $\frac{1}{2000}$ of an inch in their greatest diameter.

What may lie beyond the stage represented in Fig. 16 I am not able to say, as we were unable to keep the eggs in a healthy state after this period. The species was found in abundance, in spawning condition, at Cherrystone during July and August last, and I take this occasion to express my appreciation of the assistance of Colonel McDonald and

Messrs. Sauerhoff and Walke, who were instrumental in obtaining the eggs which were the subjects of the foregoing study.

But a few more points in relation to the development of other portions of the embryo may, perhaps, profitably engage our attention. It will be noticed that there are over eighty muscular segments or somites represented in the body of the embryo shown in the egg in Fig. 11. This very large number is unusual in bony fishes at this stage of development; less than half as many are to be observed in the young shad, cod, or mackerel at the same stage. In explanation of this difference we can only suggest that, since the muscular somites of the adult silver gar are vastly more numerous than those of the three aforementioned species, we should expect the number in the embryo *Belone* to exceed those of the other species at a very early period, which is found to be the fact.

The breast fins *f* are developed early; the first rudiment appears in Fig. 11, and they increase in size progressively from that stage onwards; at the same time they are gradually pushed farther forwards, and their bases assume a vertical position as in Fig. 16.

The vent *x*, with the growth and prolongation of the tail backwards, communicates with the exterior of the body, as shown in Figs. 14 and 16. The intestine extends forwards from it, but the mouth will apparently not be developed until considerable progress has been made beyond the stage represented in Fig. 16. There is an embryonic urinary vesicle or bladder, *b*, behind and above the vent, which is connected with the segmental ducts anteriorly. The liver is still but slightly developed.

The mid-brain is the most massively developed portion of the neurula, and consists of a pair of large, flattened, saccular outgrowths, which are developed from the upper wall of the second cerebral vesicle, which partly cover the cerebellum behind and the lower part of the brain at the sides. The cavity inside the brain is spacious in the embryos of *Belone*, as is indicated in Figs. 12 and 14; the primary vesicles are as yet but little modified in our latest stage.

Of the history of the development of the unpaired fins, these stages tell us but very little, but there was a slight dorsal and ventral natatory fold developed on the tails of the oldest embryos.

Of the relations of mesoblast to that of the hypoblast and epiblast, we clearly know that the mesoblast of the muscular somites ends abruptly on either side of the body between the upper and lower embryonic layers. In Fig. 14 the epiblast and hypoblast are indicated by two diverging lines which end at the sides of the body just in front of the breast fins. This figure shows in optic section the space between epiblast and hypoblast which runs along the whole length on either side of the body of the embryo. The epiblast amounts up over and covers the embryonic body consisting of the muscular mesoblast, spinal cord and brain, or neurula, and the notochord, segmental tubes and intestine; the hypoblast on the other hand passes beneath all of these.

The great bulk of the body is therefore inclosed between the epiblast and hypoblast; the segmentation cavity extends in reality all round the embryo's body up to the point where the mesoblast ends, and from this point all round the yelk between the epiblast and hypoblast after the latter has been enveloped by the blastoderm. Usually the mesoblast is freed from contact with the hypoblast for some distance beneath the head; in the space which results the heart is developed as a ventral mesoblastic outgrowth of cells annular at first, tubular at last, and soon divided into three principal chambers separated by two constrictions, which are not at first truly valvular. The space around the yelk is now continuous with the heart space or pericardiac cavity; the latter is indeed a part of the segmentation cavity; into this space the blood corpuscles of *Belone* are budded from the yelk through the intermediation of the hypoblast inclosing the latter. The vessels themselves appear to be intimately related to the hypoblast, and appear indeed to be placed between it and the epiblast, but to make their progress mainly along the former, plowing channels through it and the adjacent yelk. The mode of forcing or breaking open channels from one vessel to another over the yelk of *Belone* is well shown in Fig. 13, where the blind beginnings of vessels are arising at *c*, *c*, *c*, and two such from the larger vessels have met and joined but a short time since so as to connect the larger channels together. The median vessel which traverses the yelk is fed by the caudal vein behind; the lateral venous arcs *v' v''*, on the other hand, are fed directly from the cardinal veins.

It is a very significant fact that the segmentation cavity plays a very important part in the process of the formation of the blood and the incorporation of the yelk into the body of the embryo. There is no more reason why the segmentation cavity should disappear in the germinal disk of the fish-egg than in the segmenting egg of the amphibian, where it actually is as intimately concerned in the formation of the heart as in the fish, according to the evidence of the plates of A. Goette's classical *Entwickelungsgeschichte der Unke*, but this, I am aware, is not that embryologist's view of the matter. Kupffer* has advanced another view which it is important to notice in this connection, as it is very different from the one advanced by the writer in the foregoing pages. He supposes that there is a mesoblastic layer surrounding the yelk besides the epiblast and hypoblast, and which lies between the two latter. The blood, according to him, originates by germination from the hypoblast between the latter and the mesoblast. The origin of the heart is described essentially in the same way as it has been observed by the writer. Kupffer in all his writings has, however, completely overlooked the fact that the segmentation cavity of the fish-egg persists, and he was not, therefore, in a position to estimate its importance in relation to the development of the blood. As to the mesoblastic layer said to

*Beobachtungen über die Entwickelung der Knochenfische. Arch. f. mik. Anat. IV, 1868.

intervene between the hypoblastic and epiblastic layers which cover the yelk, sections through whole ova in various stages of development have thus far failed to show its existence, except in the salmon, in which it is quite evident in sections of advanced embryos. Even in the latter I am not sure that it extends entirely over the yelk. Œllacher has apparently understood the relations of the segmentation cavity much in the same way as the writer, except as to the heart.

COMPARISON OF THE TELEOSTEAN OVUM WITH THAT OF OTHER VERTEBRATES.

A comparison of the different types of vertebrate ova will be useful as leading to a clearer comprehension of the true nature of the yelk in the teleostean egg. The eggs of the common frog (*Rana*) and *Bombinator* undergo total segmentation in the process of development. There is no distinct vitellus or yelk, and the yelk of the fish egg is apparently not homologous with any part of the amphibian ovum. There is, however, an almost complete homology between the germinal disk and blastoderm of the fish and the whole of the amphibian egg. The completeness of the homology is impaired only by the peculiar way in which the neurula or brain and spinal cord and the intestine are developed in the fish. The fish egg may be regarded as the frog's ovum plus a large store of food, which may be either homogeneous or heterogeneous, and which at first takes absolutely no share in the process of segmentation. If it were possible to place a frog's egg on a sphere of protoplasm several times its own size and cause it to spread out and gradually grow over the latter so as to completely inclose it and yet develop perfectly, the condition which obtains in the fish ovum would be very nearly attained for the amphibian. The segmentation cavity, which appears in the germinal disk at an early stage of development of the fish, is perfectly homologous with a similar cavity in the egg of the amphibian, except that in the fish, instead of remaining a simple cavity it has been so greatly modified by the peculiar way in which the disk of cells in which it is contained is obliged to spread and grow over and around the yelk that it is at first not easy to see a likeness between the two types. The development of the tailed Batrachians and of the Lampreys is very similar to that of the frog, and their ova undergo total segmentation. The development of the ova of the genus *Lepidosteus* is probably not essentially different from those of the typical teleostean. The process of spreading and inclosure of the yelk by the blastoderm has not been observed in the bony gar, but, as far as I am able to judge from the account given by Balfour (*Comp. Embryol.* ii, 91–98), a segmentation cavity is probably formed, and the differentiation of the embryonic layers is apparently not essentially different from the same processes as observed in teleosts by various persons besides the writer. Fig. 58 in the work just referred to, and relied upon by Balfour to show the segmentation of the egg of *Lepidosteus*, appears to me to be taken from

a specimen preserved in alcohol, in which that reagent has produced the appearance of partial segmentation of the yelk. The germinal disk is represented above with the surface of the cells flattened, probably by the contraction of the egg membrane in a preservative fluid. The yelk of teleosts, as in the egg of *Elecate*, for example, is sometimes apparently divided into large cells, but such they are really not; they are merely homogeneous masses of protoplasm involved in a different kind of yelk protoplasm. To sum up the matter, the comparatively full account of the later development of *Lepidosteus* given by Balfour, and our lack of knowledge in regard to the stages immediately following the segmentation of the germinal disk and attending the formation of the cleavage cavity and blastoderm, lead me to conclude that it is probable that it will be found upon further investigation that the development of that form is almost identical with that of the ordinary teleostean type.

The development of the sturgeon when compared with the teleostean differs from the latter mainly in the way in which the yelk is inclosed by the intestine. This is certainly anomalous and not a little puzzling, as it is the only vertebrate type yet known in which such an extraordinary state of affairs has been shown to exist, and it is desirable that this observation of Salensky's should be confirmed in our common American species. The development of the germinal disk and blastoderm, from the account given of it by Kowalewsky, Owsjannikow, and Wagner* does not differ essentially from that seen in the teleostean egg. There is the same gradual envelopment and inclosure of the yelk by a blastoderm with a thick rim, which makes the statements to the effect that the segmentation is total appear at first to be founded upon doubtful evidence; even Balfour admits that it "approaches the mesoblastic type more nearly than the segmentation of the frog's egg." The point where the blastopore closes appears to be the homologue of the anus of Rusconi in the frog's egg, which is not the case in either the teleostean or *Lepidosteus*. The three ichthyan types, however, appear to agree pretty closely in the formation of the segmental organs, muscle segments, notochord, heart, and brain. In the blastoderm of the sturgeon there is apparently a thick rim as in the teleostean, which is mainly mesoblastic, and which in all probability contributes towards the formation of the caudal plate, and the posterior muscular segments, as in the latter. The segmentation cavity, according to the figures of Kowalewsky, Owsjannikow, and Wagner, appears to be persistent as in the teleost, and, if Salensky's representations are to be trusted, it probably enters into the formation, not only of the body cavity, but also that of the heart.

The principal difference between the blastoderm of the typical teleostean ovum and that of the Elasmobranch appears to arise from the mode in which the germinal disk continues to spread over the yelk for some time after the embryo has been formed and raised above the lat-

* Bulletin de l'Acad. Imp. des Sci. de St. Petersburg, XIV. 318–325. 1870.

ter upon an umbilical stalk, so that the portion of the blastodermic rim which still remains, but is separated from the embryo, and which will finally coalesce some distance behind the umbilical stalk, is probably not homologous with any part of the rim of the blastoderm of the teleostean. It is clear, at any rate, that this part of the rim of the blastoderm of the Elasmobranch takes no share in the formation of the caudal plate, and indirectly of the tail end of the body, as happens in the teleost. To urge the example of the Elasmobranch blastoderm, as Balfour has done, in refutation of the arguments of His and Rauber in relation to the part taken by the blastodermic rim of the germinal membranes of the teleost in the formation of the body, is therefore hardly fair.

As already stated in my paper on the development of the Spanish mackerel, the teleostean ovum is remarkable for the way in which the superficial layer or pellicle of germinal protoplasm, destined to form the germinal disk, migrates towards one pole of the vitellus to aggregate into a biscuit-shaped germ-mass. The process has been studied by the writer in detail in the egg of the cod (*Gadus*), where, owing to the low temperature of the water in which the eggs develop, it requires some time for its completion, so that it may be studied very minutely. It appears that the nucleus undergoes disintegration or rearrangement in the fish ovum before it leaves the ovarian follicle in which it grew. The nucleus in young ova is observed to be embedded in the center of the ovum; as the latter acquires maturity it migrates toward the surface and its contents are apparently broken up to be involved partly or wholly in the peripheral germinal protoplasm. In some teleostean ova it appears that the germinal disk is formed at the time of oviposition, but this is not the case in any of the species studied by the writer. In the cod, for example, the germinal disk was not formed until about four hours after impregnation. In this species, as well as in *Belone* and *Cybium*, the germinal layer of protoplasm from which the germinal disk is developed is a distinct external layer enveloping the true vitelline protoplasm. It appears that in some species this peripheral layer of protoplasm is connected with the interior of the vitellus by strands or processes of itself which pass inwards between the vitelline corpuscles, often forming an intricate investing matrix in which the latter are embedded. Notwithstanding all these modifications, however, the portion of the ovum which is directly influenced by the act of impregnation is the germinal disk alone, which in turn has been derived from the external germinal pellicle. The vitellus is, throughout the whole of development, passive; as the embryo is developed, the heart, through the intermediation of the segmentation cavity and blood vessels, becomes, in part, the means by which it is absorbed, the process being assisted by the formation of free nuclei in its substance as well as by germination, and, perhaps, by intussusception or absorption by the overlying hypoblast itself. The theory of the *intermediary layer* proposed by the writer, in the essay on the develop-

ment of the Spanish mackerel, in which it was assumed to be derived from the germinal pellicle, simplifies our theory of the constitution of the teleostean ovum. But I find myself unable to clearly determine its presence, as understood by Van Bambeke, in some forms, as in *Belone* and *Alosa*, for example. This layer may retain in it some part of the original nuclear matter of the egg, which may be the effective agent in reducing and effecting the incorporation of the substance of the vitellus by the formation of free nuclei from part of the original nuclear substance which has remained in the *intermediary layer*, which is immediately in contact with the yelk. But I have shown good reasons, as they have appeared to me, for regarding the *intermediary layer* as really equivalent to the hypoblast. If this view be sustained, and no evidence to the contrary derived from sections made during the early stages has yet been brought to light, either by the researches of myself or others, it would appear that we may rightfully maintain that the blastoderm of the fish is the homologue of the whole of the amphibian or marsipobranch ovum, and that the yelk has been superadded and is not directly concerned in the process of development, at least not until about the time the tail of the embryo begins to be budded out, shortly after which the heart is developed and begins to pulsate. The migration of the nucleus of the teleostean egg towards the surface and apparently into the peripheral germinal matter is, I apprehend, a very different thing from what occurs in the ova of the lamprey and frog, though upon comparison they present a superficial resemblance. The behavior of the ovum of the sturgeon, according to Salensky, appears to be similar to that of the teleost in respect to the formation of the germinal disk; the nucleus, too, seems to undergo disintegration into fragments.

Summarizing the arguments presented in the foregoing pages the following conclusions appear to me to be warranted:

1. The germinal disk of the teleostean egg is homologous with the whole of the amphibian and marsipobranch ovum.

2. The yelk, while it is in intimate organic union with the blastoderm, may be regarded merely as a nutritive appendage to the teleostean egg from the center of which the nucleus has migrated at about the end of intraovarian development into the germinal pellicle or disk, leaving the yelk a passive structure, the presence of which has greatly modified the mode of development of the blastoderm.

3. The rim of the blastoderm is more or less extensively transformed into the body of the embryo as argued by His and Rauber.

4. The difference between the development of the ganoids and teleosts is much less than between the former and amphibians.

5. The blood in *Belone* is developed directly from the yelk through the intermediation of the hypoblast, quantities of its corpuscles being found in the heart or pericardiac chamber.

6. The intestine of the teleost embryo is formed from behind forwards by splitting of the hypoblast, and not by an invagination conterminous

behind with the neurula or spinal canal, as in the Amphibian and Marsipobranch, and there no evidence to show that the point where the rim of the blastoderm closes is comparable to a blastopore, or to the anus of Rusconi.

7. The gastrula of the teleost is extremely modified on account of the extreme flattening and epibolic mode of growth of the blastoderm over the yelk, but the type of development is, in reality, similar to that where there is a neurenteric canal developed as in embryo sharks, lampreys, and frogs, since the vent is always broken through long before the mouth, and there is a strand of cells representing the neurenteric canal.

8. The blastoderm of the teleost may be regarded as a very depressed concavo-convex hollow sack resting on the yelk, the hollow space beneath it representing the persistent cleavage cavity. One side of the blastodermic disk or sack is filled with mesoblast cells, from which the somatopleure and splanchnopleure are derived, where the embryo is formed; the intestinal lumen is, at first, a narrow transverse split in the hypoblast which extends forward, eventually prolonging the enteric cavity beneath the head.

9. The uppermost or epiblastic layer of the blastoderm, several cells deep, roofs over the cleavage cavity, the hypoblast forms its floor, the rim of the blastoderm contains mesoblastic cells, which, as the germinal membranes close over the yelk form the caudal-plate which is continuous on either side with the medullary or muscle-plates at the sides of the body of the embryo. The caudal-plate eventually enters into the formation of the tail and caudal muscular mesoblastic somites, its hypoblast into the formation of the anal end of the intestine.

10. The cause of the at first flattened lumen of the intestine is probably to be sought in the very depressed and modified type of blastoderm of the teleostean, which differs widely from that of all other vertebrates. The lumen of the intestine gradually becomes round.

The embryo develops at the edge of the blastoderm in Teleosts, Elasmobranchs, and Ganoids, but only a small portion of the blastodermic rim appears to be appropriated to form the embryo in the Elasmobranch. This eccentric development of the embryo is in strange contrast with that of the Amphibian and Lamprey, and not less so when compared with the mode of development of reptiles, birds, and mammals where the embryo develops in the center of the blastoderm, and where the yelk, when present, appears to be merely nutritive and accessory, as in the teleostean egg. Only in the case of *Zoarces* is there an approach toward the formation of an umbilical stalk, according to Rathke, but even there it is not developed until some time after the blastoderm has closed over the yelk.

EXPLANATION OF REFERENCE LETTERS USED IN THE PLATES.

a. Venous end or sinus of heart.
b. Urinary vesicle or bladder.
ba. Bulbus aortæ of heart.
c. Blind capillary prolongations from the larger blood-vessels on the surface of the yelk.
e. Head end of developing embryo.
f. Rudiment of breast fin.
g. Germinal disk.
k. Kupffer's vesicle.
o. Optic vesicles; rudiments of the eye-balls.
p. Pericardiac or heart space.
r. Thickened rim of blastoderm.
s. Muscular or elastic band binding the ventricle to the floor of the heart space.
sc. Segmentation cavity.
v. Median vitelline blood-vessel.
v' v''. Right and left vitelline blood-vessels.
ve. Ventricle of the heart.
w. Wreath of cells around the germinal disk which enter into the formation of part of the blastodermic rim *r*.
x. Vent or anus.
z. Point where the caudal vein passes into the median vitelline blood-vessel.

EXPLANATION OF PLATE XIX.

☞All of the figures except 13 and 15 are enlarged twenty-one and a third times the natural size.

Fig. 1.—Egg of the silver gar in its membrane, with the tentacular filaments attached to its surface, 3 hours and 23 minutes after impregnation. The germinal disk *g* at its upper pole has been segmented into 8 cells.

Fig. 2.—Germinal disk, 4¾ hours after impregnation, divided into 16 cells.

Fig. 3.—Germinal disk, 10 hours after impregnation, showing the formation of a wreath of cell, *w*, round its margin.

Fig. 4.—Blastoderm of silver gar, viewed from above, 24 hours after impregnation to show the form and extent of the segmentation cavity.

Fig. 5.—Blastoderm of silver gar, viewed from above and obliquely, 31 hours and 20 minutes after impregnation, showing the body of the embryo budding out from the edge of the blastodermic rim.

Fig. 6.—Blastoderm nearly inclosing the vitellus, 43 hours and 40 minutes after impregnation, eyes *o*, muscular segments *so* and Kupffer's vesicle *k* are developed.

Figs. 7 and 8.—Head and tail ends of embryos, 51 hours after impregnation.

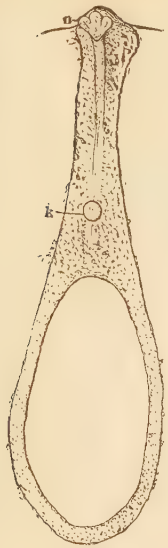
EXPLANATION OF PLATE XX.

Fig. 9.—Embryo silver gar with the head seen in optic section, the tail end and the conjoined oval blastodermic rim seen through the transparent vitellus, which is not represented, 51 hours after impregnation.

Fig. 10.—Embryo one hour later, represented without the vitellus, the number of muscular segments has greatly increased in number, and the blastoderm has closed over the yelk.

Fig. 11.—Embryo silver gar, seen from the side as a transparent object, 70 hours after impregnation. The tail is about to begin to bud out behind, the heart is formed but is still tubular, and a vessel passes forward around the yelk back to the tail and on forward through the body to the hind end of the heart. The direction of the blood

TYLOSURUS LONGIROSTRIS.



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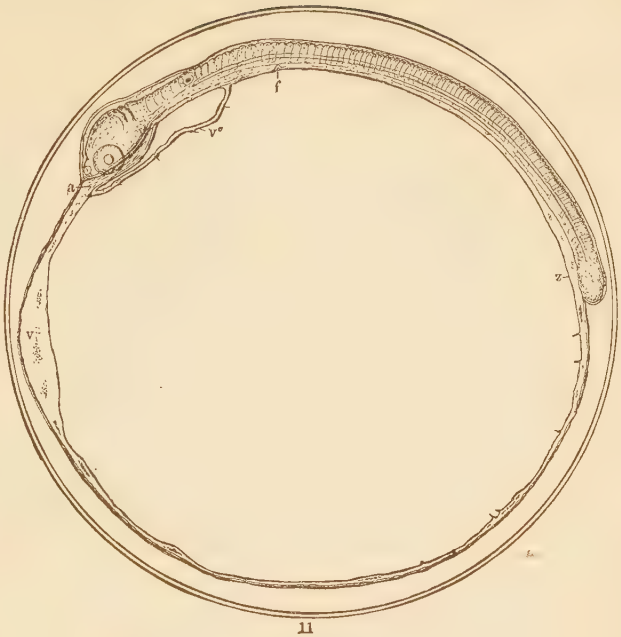

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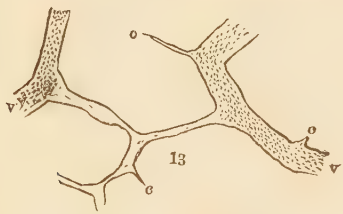

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TYLOSURUS LONGIROSTRIS.

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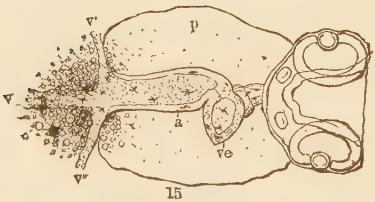

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TYLOSURUS LONGIROSTRIS.

current is from the head to the tail. There are already over 80 muscular segments formed, and the breast-fin is developing at *f*.

Fig. 12.—Embryo, 94½ hours old, viewed as a transparent object. The notochord is shown as a broad black line, and the lateral yelk-vessels *v'* *v''* are much more developed than in Fig. 11.

Fig. 13.—Diagram to show the origin of the mode of anastomosis of the larger vessels, enlarged 52 times.

EXPLANATION OF PLATE XXI.

Fig. 14.—Embryo silver gar, 116 hours and 40 minutes after impregnation, showing the further development of the heart and blood-vessels traversing the surface of the yelk. Those on the opposite side of the yelk are indicated by the dotted lines. Pigment cells have made their appearance on the body beneath the superficial epiblast and on the yelk and the heart. The intestine and urinary vesicle *b* are well developed, as seen in the tail end of the embryo on the opposite of the egg through the vitellus.

Fig. 15.—Sketch of heart and vessels which empty into it in an embryo 140 hours old; the formation of the blood is in active progress where the vessels converge to join the heart, which is now blotched with pigment cells of two colors in life. Enlarged 26 times.

Fig 16.—Embryo silver gar, viewed from the side as a transparent object 165¾ hours after impregnation, to show the progress of development of the blood vessels over the yelk on the right side. The heart or pericardiac cavity *p* is now enormously developed, and the development of blood cells is going on with great activity in its lower part, where the venous end *a* of the heart is attached. The heart itself is now greatly elongated downwardly, and is one-third as long as the whole embryo.

ON THE REARING OF WHITEFISH IN SPRING-WATER AND ITS RELATION TO THEIR SUBSEQUENT DISTRIBUTION.

By FRANK N. CLARK.

[Letter to Prof. S. F. Baird.]

I am not prepared to say whether or not eggs of the whitefish are prematurely hatched in spring-water. I take it that the question is a scientific problem for scientists to solve; that it is a point on which even "doctors disagree."

If we could "reap what we sow" from our plants of fish in bodies of water like the great lakes we would soon have a practical test of the respective value of "premature" or "retarded" development of eggs or embryos; but this is impossible, and so if there is any difference we must detect it from evidence that is circumstantial or theoretical. It seems reasonable to assume that if the little fellows are vigorous when hatched, whether of three or five months' incubation, and are released when and where aliment for their sustenance is abundant, a large percentage of those not destroyed by predaceous fishes ought to become adults. There is no difference in size and activity between fish brought out in three or six months, where the same water is used; neither are there points about the former that can be construed into evidence of abnormal de-

velopment or "prematurity." We have had a good chance to test this here, where the spring-water is raised or lowered in temperature, according to the weather, before it reaches the hatchery. Our hatching seasons are long or short, according as the winter is severe or moderate. Last year our eggs were laid in fully two weeks earlier and hatched nearly a month later than this, yet the fish of this year are equal in vigor and identical in appearance with those produced last season. But there is a very slight difference between the fry of the Northville hatchery, and of the Detroit, Toledo, and Sandusky hatcheries; the latter are a little darker, a trifle less transparent. I used to think that this difference was due to difference of hatching-periods; but since the fry of this season that hatched earlier than ever before are identical with previous hatchings, and since there is always the same difference between the spring-water and lake-water fry, no matter whether the former are hastened or retarded, I am constrained to think that the difference, which, however, is almost imperceptible, is due to the *character* rather than the temperature of the water. Last year our fish were "kept back" nearly as late as were those in hatcheries using lake-water. I know that when we made a plant at the islands (Lake Erie) the tanks of the Sandusky hatchery were full of whitefish minnows ready for distribution; and although there was not to exceed ten days in difference in times of hatching, there was that same slight difference in color and transparency.

Our spring-water is clear and sparkling, free from mechanical impurities, but holding in solution sufficient calcic salts to make it quite hard. The water used at the Sandusky and Toledo hatcheries is much softer, but is quite roily at times, and is never free from mechanical impurities. When they were laying in eggs last fall the water was so bad that they had to dispense with the wire gates through which the water discharges from the jar, as they would get clogged with sediment in a short time and overflow the jar.

We have, at the hatchery here, brought forth the young of brook trout in 80 days, and anon in 120 days; yet the former ate as readily, grew as rapidly, suffered as little loss, and in fact were the equals in every respect of the latter. The hatchery of the Michigan commission, formerly located at Pokagon, used spring-water for hatching their trout eggs, without attempting to cool it by extended exposure to the air. In consequence of using this comparatively warm water their eggs frequently hatched in mid-winter—I presume in less than 80 days, but do not not know positively. They had no trouble in rearing their fish.

I am well satisfied that where we have had a chance to test this matter, as with the young of fishes readily adapted to being grown in confinement in ponds or tanks, or "artificially" as brook trout, California trout, &c., it makes no difference whatever, either as to the appearance of the fish, or results in rearing, whether the eggs incubate a moderately short or a very long time. There must, of course, be a limit to the brevity of the

hatching-period, but where the line is to be drawn is more than I can say. We have no such chance for making such tests with the young of whitefish, as they are, of course, lost sight of when released in such vast bodies of water as the great lakes, and we can therefore only speculate as to their probable future. But if varying periods of incubation make no difference in the vigor or appearance of trout alevins, why should it with whitefish? Do not the facts in connection with trout establish a precedent, or basis, for calculations in regard to the number of adults to be produced from a given number of *any* kind of fish set free in waters to which they are indigenous, provided the latter are, like the former, protected from enemies, and have an abundance of their appropriate aliment at command? Is there anything wanting to make the premises and conclusions analogous? It is not possible to protect the little fishes from their enemies, when they are turned loose to "seek their own salvation." But it *should* be incumbent on the fish-culturist to see to it that they are released only when and where their particular food is found; and not only found, but in sufficient quantities for the purpose, so that we might reasonably expect as large percentages to survive, outside of those destroyed by enemies, as we do of those grown in our ponds.

It is one thing to hatch a large number of fish; it is quite another to know just when and where to place them within the jurisdiction of conditions absolutely essential to their existence. The former is now a matter of comparative ease; but as this amounts to nothing, so far as the results sought after are concerned, if the proper conditions are not subsequently supplied, there ought to be a certainty, which scientific investigation alone must determine, that these conditions *do* exist. The tendency with fish-culturists generally has been to see how many fishes can be brought into existence, and to see how cheaply it can be done, then planting them with a reckless indifference, trusting to "luck" for good results.

Perhaps, though, this random and indiscriminate distribution is the best that can be done in many instances where the exact requirements are not known.

Professor Forbes' recent researches to determine the food of the young of whitefish throw a good deal of light on this subject, that will apply with equal force, in some respects, to other fishes; and his prospective experiments will doubtless reveal still greater light, if indeed they do not, incidentally, settle the question of prematurity so far as the young of whitefish are concerned. What he proposes to do, as I understood him in a recent conversation on our way from Racine to Chicago, is to set two or more seines or prisons in Geneva Lake, Wisconsin, where the alleged food of the young whitefishes, entomostraca, &c., is found.

Into these separately will be put some fry from the Northville hatchery—if I can keep them alive until he is ready for them—and some from the Detroit hatchery, later on. If the little fellows partake of the entomostraca freely and thrive, this will verify Mr. Forbes' prior conclusions that this is their earliest food. If the Detroit fish live and mine do not, it will look as though mine were premature, unless indeed they

shall have been kept too long before the test is made. If the Detroit fish suffer as great loss as mine, it will look as though there was no advantage or nothing to be gained by retarding the eggs, so far as the vigor of the fish is concerned. If Mr. Forbes finds that the entomostraca are much more abundant later on than when he made investigations at Racine the day following our plant of fish at that point, it will signify that we should keep back the eggs, so that the fry may have the greatest possible amount of food at their disposal. Or, if Mr. Forbes' experiments show, or, if it can be shown, that our spring-water brings out weak or immature fish, then certainly other water should be used, even though the whitefish branch of the work is removed to some other locality, which I shall be perfectly willing to have done.

We have other water near the hatchery (branch of river Rouge, see map), that is as cold as can be found anywhere during the winter; but it is lower than the hatchery, and would have to be pumped. This would entail some expense, but would give us more water for trout purposes. We could also, by running varying proportions of spring and creek water on different sections of eggs (whitefish), hatch them at will, as wanted for distribution.

Another good way, too, if it is thought best not to hatch whitefish at Northville in the spring-water, is to put up an inexpensive hatchery adjacent to some good spawning grounds, as, for instance, at Alpena. At such a point, the hatchery could be filled at a very moderate expense, as every fisherman would lend a hearty co-operation. By using jars only and having no shipments to make, two men could easily care for a very large number of eggs. Enough could be sent on to Northville, say five or ten million, to fill orders from other points, making this headquarters for shipping, correspondence, &c.

Our whitefish hatched in from 75 to 90 days this year—an unusually brief period; but since they are the exact counterparts, both in appearance and vigor, of the fish of previous hatchings, I am forced to admit that the opinions I have hitherto held in regard to this matter were erroneous. But I think there is a very good reason why the use of spring-water for hatching these fish should be discontinued, unless, indeed, we can devise some means of reducing it to the proper temperature to "keep the fish back" later than this; for, although the "premature" fish are perfectly normal, it is altogether probable that the proper food exists in much greater abundance later on.

I can but think, too, as Professor Forbes says, substantially, that a great mistake is made in planting the fish in such large numbers in one place. The water should be teeming with the appropriate food at the time and place the fish are set free, to meet the requirements of so vast a number of minnows as are usually released in one place.

According to Professor Forbes' recent investigations off Racine, each minnow would have to skirmish around through a vast deal of water to find sufficient nourishment, even though he had no comrades with which to divide the spoils. Grown fish might easily migrate to rich feeding-

grounds; but this can hardly be expected of those of such tender age. I think they should be as widely scattered as possible when turned loose. Doubtless more of them would get eaten up, but less would starve to death. This should apply to other kinds of fish as well. It might be argued that the parent fish themselves congregate in large numbers in one locality to deposit their eggs. This is true, but it is very doubtful if any hatch except those isolated individuals carried into the crevice of some rock or reef, thus becoming protected from spawn-eaters and the confervaceous growth that must generate and destroy all eggs *en masse;* so that but a comparatively small number of the young are turned out, and these are considerably scattered.

Touching on these points, I will quote from Professor Forbes' recent letters:

From February 3: "I have not forgotten the food of the young whitefish, but have kept the subject in mind in making collections from Lake Michigan and adjacent waters this fall and winter. Entomostraca of great variety occur in considerable numbers in the lake at all seasons, as is shown by surface collections made there by me in October and November, off Chicago, and in Grand Traverse Bay, and by the straining of the water supply of Chicago. A fine lot of the common forms was obtained by the latter method, January 20, of this year. Everything of the sort is much more abundant, however, about the time of the melting of the snow than at any earlier period, and the chances of young fish finding sufficient food would certainly be much better then than earlier." * * *

Mr. Forbes had arranged to be with us on our trip with fish to Racine and Sheboygan, but missing our train, came on to Racine the day following our plant of fish. He then made his searches for entomostraca, and returned with us to Chicago that evening. A few live fish were found in one of the cans, and these Mr. Forbes took home with him. Since then he writes, as follows:

"The little whitefish came through all right, and I have about two-thirds of them yet in an aquarium. I have kept them supplied with entomostraca from pools about here, but, although the little fellows will follow a cyclops around for some time, making little jumps at him, and nibbling at his heels, yet I haven't seen any actual captures, and don't think that any have been made. Their teeth are already developed, but there are considerable remnants of the egg-sac remaining. I shall probably lose them all before they are positively compelled to eat, as our well-water don't seem to be altogether agreeable to them.

"I am very well satisfied that nothing much larger than a cyclops could be taken by them at first, and the small number of the larger entomostraca which I found at Racine consequently wouldn't signify *at first.* Possibly they might find a scarcity of appropriate food a little later, when they had gained strength and courage enough to attack a daphnia.

"Without really *knowing* about it, I have a strong impression that the little fishes' chances would be improved if they were as widely scattered as posssble when deposited. Certainly, if they are disposed to keep together at all after being released, any large school of them would have found poor hunting off Racine.

"I have made as careful a count and estimate as I could of the abundance of small entomostraca there, and have concluded that there were not more than one or two to the cubic foot of water, and that there were probably less than this.

"These calculations will have more value, however, after it is absolutely certain that entomostraca make the principal food of the fishes.

"I have taken the first steps towards the Geneva Lake experiment, and hope that we shall make that clinch the matter."

Mr. Forbes wrote again the same day (February 20) as follows:

"Since my letter of this morning the little whitefish have realized the situation, and the entomostraca are rapidly diminishing in number. Several of the little fellows have been bottled with *Corpusus delicti* in their bowels, always of the smallest species, cylops or canthocamptus. They pay no attention whatever to the algæ in their jar, and seem afraid of the daphnias, and larger entomostraca generally."

I have no further communications from Mr. Forbes relative to this matter.

NORTHVILLE, MICH., *February* 22, 1882.

DESCRIPTIONS OF NINETEEN NEW SPECIES OF FISHES FROM THE BAY OF PANAMA.

By DAVID S. JORDAN and CHARLES H. GILBERT.

The greater part of the months of February and March, 1881, were spent by Mr. Gilbert at Panama, in making collections of fishes for the United States National Museum. About 145 species were obtained at Panama, 80 of which are identical with species previously obtained at Mazatlan. The following species appear to be new to science, and are described in the present paper:

1. *Urolophus aspidurus.*
2. *Tylosurus scapularis.*
3. *Caranx (Carangops) atrimanus.*
4. *Sciæna imiceps.*
5. *Sciæna (Stelliferus) cricymba.*
6. *Sciæna (Stelliferus) oscitans.*
7. *Sciæna (Bairdiella) ensifera.*
8. *Odontoscion archidium.*
9. *Cynoscion phoxocephalum.*
10. *Isopisthus remifer.*
11. *Serranus (Pleetropoma) lamprurus.*
12. *Diabasis steindachneri.*
13. *Xenichthys xenops.*
14. *Pimelepterus ocyurus.*
15. *Gerres aureolus.*
16. *Gobius (Lepidogobius) emblematicus.*
17. *Microdesmus retropinnis.*
18. *Cerdale ionthas.*
19. *Citharichthys (Hemirhombus) latifrons.*

1. **Urolophus aspidurus**, sp. nov. (29410, 29307, 29454.)

Color plain brown; upper side of tail blackish; under side of body and tail white.

Disk very slightly longer than broad, its length very little less than length of tail; anterior margins of disk nearly straight, the anterior tip abruptly projecting as an exserted, narrow, triangular, prominence rounded at its end; length of exserted part about as long as the width of its base, and from half to two-thirds the interorbital width, it being longer and sharper in a male specimen, in which also the anterior margins of the disk form a less obtuse angle; distance from eye to tip of snout about one-third length of the disk. Interorbital space broad, somewhat concave, 2½ in distance to tip of snout. Eyes very small, much smaller than the large spiracles; their diameter less than half interorbital width. Width of mouth 2½ in its distance from the tip of the snout. Nostrils directly in front of angles of mouth; nasal folds forming a broad continuous flap, the edges of which are slightly fringed. Ventrals projecting a little beyond outline of disk. Caudal spine very large, its length a little more than twice interorbital width (in a large female specimen duplicated, and as long as from eye to tip of snout), its insertion well in front of middle of tail. Caudal fin long and low, the lower portion longer, beginning nearly opposite tip of caudal spine. Depth of tail with the caudal fin, about half interorbital width.

Skin entirely smooth, with the exception of a series of strong broad-rooted spines or bucklers on the upper part of the tail in front of caudal spine, and sometimes a series of minute sand-like prickles on snout, and on median line of body. These latter are present only in a large female specimen, which also has 8 spines on the tail instead of 2 as in the others. These spines are straight, sharp, directed backwards, their height about equal to width of base, which is somewhat longer than diameter of pupil.

This species is not uncommon in the Bay of Panama, and is brought into the market in company with *Urolophus mundus*. Three specimens were obtained, the largest about 18 inches in length.

2. **Tylosurus scapularis**, sp. nov. (29427, 29435, 29438.)

Allied to *Tylosurus longirostris* (Mitch.), but the tail not depressed and without cutaneous ridge.

Body slender, not compressed, as broad as deep; caudal peduncle compressed, deeper than broad, without trace of cutaneous keel, the lateral line not more conspicuous there than elsewhere, and not black.

Head long, the jaws very long and slender, narrow throughout; length of upper jaw from eye twice the length of the rest of the head. Diameter of eye about equal to interorbital width, contained 8 to 9 times in the length of the upper jaw, 3½ times in the length of the rest of the head. Teeth much as in *T. longirostris*, the small teeth forming the external band, not very small; the large teeth of the inner series slender

and pointed, scarcely compressed, about 40 on each side of each jaw. No teeth on vomer. Teeth not green.

Maxillary not entirely concealed beneath preorbital. Interorbital area with a deep scaly groove, which is broadest anteriorly; a strong ridge along temporal region separated by a furrow from a rectangular elevated area on the top of the cranium. Cheeks closely scaled; opercles naked below; scaled above. No gill-rakers. Scales not green, not very small.

Dorsal fin low, its anterior rays highest, as long as from eye to edge of opercle. Anal a little higher than dorsal, beginning farther forward. Caudal fin almost truncate, the lower rays little longer than the upper, the middle rays five-sevenths the length of the postorbital part of the head, their insertion somewhat nearer base of caudal than eye. Pectorals moderate, five-sixths length of postorbital part of head, the upper ray not enlarged. Ventrals small, half length of postorbital part of head, their insertion somewhat nearer base of caudal than eye.

Head $2\frac{4}{5}$ in length; depth 19. D. 14; A. 16; P. 10; V. 6; Lat. l. 215.

Color, in spirits, olivaceous above, whitish but not silvery below; a faint band of silvery along the sides, which becomes blackish posteriorly; this band as well as the sides of the head and the lower parts of the body rendered dusky by thick-set dark-brown points. A large distinct rounded black spot above base of pectorals. A faint dusky band along the back. Fins plain; tips of ventrals a little dusky; pectorals entirely pale. Caudal darker at tip.

Several specimens, the longest about 15 inches in length, were taken in the Bay of Panama.

3. **Caranx atrimanus**, sp. nov. (29341.)

Subgenus *Carangops* Gill; allied to *Caranx amblyrhynchus* C. & V. = *Caranx falcatus* Holbr.

Body regularly elliptical, compressed and much elevated, the dorsal and ventral curves about equal, and the greatest depth of the body nearly in the middle of the length, exclusive of the caudal peduncle. Head small, short and low, its depth rather less than its length, the upper profile descending gently to the sharp snout; jaws about equal; premaxillaries anteriorly about in the axis of the body; maxillaries narrow, reaching slightly beyond anterior margin of orbit, $3\frac{3}{5}$ in head. Each jaw with a single regular series of very small, close-set teeth, without larger teeth; no teeth on vomer, palatines, or tongue. Eye moderate, slightly longer than snout, $1\frac{1}{4}$ in interorbital width; occiput with an evident carina. Gill-rakers moderate, about 15 on the anterior limb, the longest half the diameter of the orbit. Head naked, with the exception of a patch of scales on the temporal region.

Distance from snout to origin of spinous dorsal less than length of pectorals. Dorsal spines slender and fragile, the highest equal to the distance from snout to front of pupil. A well-developed antrorse spine before the dorsal. Soft dorsal and anal similar, not falcate, the rays

regularly decreasing from the first. Highest soft ray of dorsal about half the distance from snout to base of pectoral, and somewhat longer than the highest ray of the anal. Free anal spines little developed. Dorsal and anal each depressible into a very high sheath of scales, which leaves only the last two or three rays uncovered. Caudal fin wide, well forked, the upper lobe evidently longer and more falcate than the lower, but less produced than in *C. amblyrhynchus*, the longest ray being about one-third the length of the rest of the fish. Pectoral fin very long and falcate, reaching opposite to base of seventh ray of anal, about half longer than head. Ventrals rather long, reaching beyond vent and slightly more than half way to front of anal.

Breast entirely covered with very fine thin scales; upper part of sides anteriorly with irregular series of scales which are not well imbricated. Lateral line with a strong curve anteriorly (but less arched than in *C. amblyrhynchus*), the height of the curve two-sevenths of its length, which is a little more than half the length of the straight portion; the line becomes abruptly straight opposite the front of the anal. Plates of lateral line developed along the entire length of the straight portion, the plates not large, the height of the largest one not more than half the diameter of the eye.

Head 4 in length; depth $2\frac{2}{5}$. D. VI–I, 29; A. II, I, 25; Lat. l. 60 (all plates).

Color, blackish olive above, dusky yellowish below, with silvery luster. Top of head, snout, and a large diffuse blotch on upper part of opercle black; cheeks and lower parts of head thickly dusted with large brown points. Vertical fins dusky, the caudal and anterior rays of anal with much greenish-yellow; ventrals largely white. Pectorals dusky olive, the axil and a large black blotch on both sides of the fin at base *jet black*. This blotch covers the base of all the rays of the pectoral except the lower, and extends on the fin for a distance greater than one-fifth the length of the fin. Inside of mouth and lining of opercles not black.

A single large specimen, 12 inches in length, was taken in the Bay of Panama.

4. **Sciæna imiceps**, sp. nov. (29432, 29481, 29489.)

Allied to *Sciæna ophioscion* (Gthr.).

Body deep and compressed, the back considerably elevated, the caudal peduncle short and deep. Head very small, narrow, and low; the snout bluntly pointed, the profile from the nostrils to the interorbital region not steep, thence rising steeply with a considerable curve to the base of the dorsal. Depth of the head at the middle of the eye equal to the length of the snout and eye, and about equal to the greatest thickness of the head. Interorbital space narrow, little convex, little wider than eye, 4 in head, about equal to length of snout. Preorbital wide, gib-

bous; preopercle somewhat cavernous. Eye rather large, a little shorter than snout, $4\frac{1}{2}$ in head.

Mouth small, inferior, horizontal, the lower jaw much overlapped by the snout, its tip extending little forward of the nostrils. Maxillary extending to opposite middle of eye; premaxillaries in front, far below level of lower edge of eye; length of gape, $3\frac{2}{3}$ in head. Teeth very small, nearly as in *S. fürthi*, in narrow villiform bands in both jaws, the outer row in the upper jaw enlarged.

Preopercle armed with strong radiating teeth, about three near the angle larger than the others, none of them directed downward. Chin with two large pores, preceded by two smaller ones, and without symphyseal knob. Pseudobranchiæ small. Gill-rakers (as in *S. ophioscion*) minute, slender, not longer than nostril.

Scales roughish; lateral line strongly curved, becoming straight opposite middle of anal fin.

Spinous dorsal rather high, the spines not very slender, the second spine a little stronger than the others, $2\frac{1}{4}$ in head; the highest spine $1\frac{3}{4}$ in head, considerably higher than the soft rays. Soft dorsal and anal fins scaled a little more than half way up. Caudal double truncate, the middle rayed moderately produced, the upper angle acute, the lower rounded; middle rays of caudal $1\frac{2}{5}$ in head. Anal inserted nearly under the middle of the soft dorsal, the distance from its first ray to base of caudal $3\frac{1}{6}$ in length of body. Second anal spine shortish, but rather strong, somewhat shorter than the first soft ray, its length considerably greater than its distance from the vent and equal to half the length of the head. Ventrals small, reaching about half way to anal, not to tip of pectorals, which are long, scarcely shorter than head.

Head $3\frac{2}{3}$ in length; depth 3. D. XII, 25; A. II, 8; scales 5-51-9.

Color in spirits: Dull brown above; belly white, but not silvery; upper fins brown, the spinous dorsal dusky at tip; anal dusky, thickly studded with dark points; ventrals and pectorals dusky; a faint band of dark points from base of pectoral straight to caudal, bounding the dark color of the upper parts. Peritoneum white; lining of opercles partly black.

Three specimens of this species, each $6\frac{3}{4}$ inches in length, were taken in the Bay of Panama.

This species is evidently allied to *S. ophioscion*, although differing considerably in details of form. It has also some points in common with the members of the group called *Stelliferus*.

Sciæna ophioscion does not appear to us to differ *generically* from *S. vermicularis* (Gthr.), or from *S. ocellata* (L.), the type of the group called *Sciænops* by Professor Gill. We are moreover unable to see that the latter group differs from the typical species of *Sciæna* (*aquila*) in any important respect, the small size of the anal spine in "*Sciæna*," as distinguished from "*Corvina*," being a character of no systematic importance whatever.

5. **Sciæna ericymba**, sp. nov. (29338, 29433, 29466, 29477, 29479, 29494.)

Subgenus *Stelliferus* Stark = *Homoprion* Holbrook.

Allied to *S. fürthi* (Steind.).

Body short and stout, little compressed, the back somewhat elevated, the caudal peduncle slender. Profile nearly straight and not steep, from the scarcely truncate snout to the occiput, where an angle is formed, the rise thence to the base of the dorsal being more steep.

Head formed much as in *S. oscitans* and *S. stellifera*, very broad, with very cavernous preopercle, preorbital and cranium. Interorbital space broad, flat, its least width equal to snout and half of eye, about twice diameter of the small eye, $2\frac{4}{5}$ in length of head. Supraocular ridges prominent; a cross-ridge on forehead connecting nostrils.

Mouth terminal, oblique, smaller and more oblique than in *S. fürthi*, its gape $2\frac{4}{5}$ in length of head; premaxillaries in front on the level of lower part of eye; maxillary reaching to opposite posterior border of pupil; front of premaxillaries extending further forward than tip of snout (in *S. oscitans* the snout protrudes a little; in *S. fürthi* considerably).

Teeth much as in *S. fürthi;* upper jaw with an external series of small, slender teeth, behind which are two or three rows of smaller teeth; lower jaw with a narrow villiform band. Pores of chin obscure; symphyseal knob small.

Edge of preopercle with several (about 7), rather strong, slender, radiating teeth; the three near the angle largest, none of them directed downwards or forwards. Gill-rakers long and slender, much more than half the diameter of the eye; pseudobranchiæ small. Suprascapula prominent, with slender teeth.

Scales large, rather strongly ctenoid; lateral line very strongly arched, becoming straight just in front of insertion of anal. Vertical fins covered with small scales, as in other species of *Stelliferus* and "*Pachyurus*."

Spinous dorsal low, the second spine much stouter than those succeeding, stiff; other spines very slender and flexible; second spine as long as snout and half of eye; third spine two-fifths length of head. Soft dorsal low, rather lower than the spines. Caudal fin rhombic, the middle rays longest, three-fourths length of head; least depth of caudal peduncle two-fifths length of head.

Anal fin small, not very far back, its last rays well in front of last of dorsal; distance from its first ray to front of caudal $3\frac{1}{4}$ in total length of fish (to base of caudal); its distance behind the vent about equal to the length of its second spine. Second anal spine 4 in head, stout, but shortish, lower than the soft rays. Ventrals moderate, not reaching vent, coterminous with the pectorals, which are rather long, four-fifths length of head.

Length of head equal to greatest depth of body, $3\frac{1}{3}$ in length.

D. XII, 24; A. II, 7; scales 5–48–8 (rows).

Coloration dark brownish above, white below; everywhere with dark

points; upper parts with bright bluish reflections; lower parts with silvery luster; a dark temporal blotch; lower jaw black within, behind the front teeth. Fins all dark brownish, the pectoral, anal, and ventrals quite black, with minute dark points; tip of spinous dorsal black. Lining of opercle dusky; peritoneum silvery.

Six specimens obtained in the Bay of Panama. All of them are from 6 to 7 inches in length, and as they are evidently mature, this species is probably one of the smallest of the Sciænoid fishes.

Its resemblance to *S. fürthi* is quite strong, but the armature of the preopercle, the form of the snout and mouth, and the color of the lower fins, at once distinguish it from both *S. fürthi* and *S. oscitans*. The cavernous structure of the bones of the head reaches in this species an extreme.

6. **Sciæna oscitans**, sp. nov. (29298, 29299, 29319, 29326.)

(Subgenus *Stelliferus* Stark; allied to *Sciæna fürthi* (Steind.) and *S. oscitans* J. & G.

Body oblong, the back somewhat elevated; head very wide and heavy, almost quadrate, flat above; cheeks nearly vertical; cranium above, as well as preorbital and preopercle, cavernous, yielding to the touch; snout heavy, projecting a little beyond premaxillaries, much broader than long, its length 4 in head. Interorbital space very broad and flat, its breadth $2\frac{2}{5}$ times in length of head. Greatest width of head two-thirds its greatest height. Eye moderate, its diameter equal to half the interorbital space. Supraorbital rim slightly elevated.

Mouth very wide and oblique, the lower jaw included; length of gape twice in length of head ($2\frac{3}{4}$ in *S. fürthi*); premaxillaries anteriorly on the level of the lower part of pupil; maxillary reaching well beyond the posterior margin of the orbit. Chin with a small but distinct knob, the pores around it not well marked.

Teeth small, not forming villiform bands, in two rather irregular series in each jaw, the outer teeth in upper jaw somewhat enlarged, the large teeth fewer in number and larger than in *S. fürthi*.

Gill-rakers numerous, very fine and slender, the longest about two-thirds diameter of orbit, about 28 on anterior branch of outer gill arch. Pseudobranchiæ quite small.

Preopercle with its margin evenly rounded, the upper and lower limbs nearly equal, the membranaceous margin minutely serrulate; above the angle is a short, very strong spine directed backwards, and at the angle is a similar one directed obliquely downward and backward; no other stiff spines on the preopercle.

First and second spines of the dorsal strong and inflexible, second spine about one-third length of head; third spine longest, about half as long as head, and like the succeeding spines very slender and flexible; eleventh and twelfth spines longer and stronger than the tenth. Soft dorsal anteriorly about as high as the third spine. Anal short, its second spine long and very strong, much stronger than second dorsal spine and longer than the third, its length rather more than half the

length of the head. Distance from vent to second anal spine considerably less than length of second anal spine. Caudal rounded, the middle rays produced, its length a little less than that of head.

Pectorals broad, reaching about to vent, about equal to length of head. Ventrals not reaching nearly to vent.

Soft dorsal, anal, and caudal fins thickly scaled to their tips; the spinous dorsal with a thick scaly sheath at base, each spine with a series of scales; other fins more or less scaly.

Scales large; lateral line with a wide low curve anteriorly, becoming straight in front of origin of anal; tubes of lateral line branched anteriorly.

Head $3\frac{2}{3}$ in length; depth 3. Dorsal rays XI, I, 22; Anal II, 8; scales 6–53–9 (rows); 47 pores.

Coloration dusky above, pale below, with some silvery luster; middle of sides conspicuously punctulate; upper fins all brownish, punctulate with darker; ventrals, anal, and pectoral pale; the anal and pectoral dusted with dark points. Opercle blackish within; peritoneum dusky-silvery. The coloration of *S. fürthi* is very similar, but paler, the lower fins quite pale; peritoneum pale.

Four specimens, the largest 8 inches in length, were obtained at Panama. The characteristic physiognomy of the group called *Stelliferus* reaches in this species an extreme.

One specimen of *S. fürthi* (Steind.) was obtained at Panama. This species differs in the much smaller and more nearly horizontal mouth, which is overpassed by the snout; the lower preopercular spine is directed downward and *forward*, and there is no knob at the symphysis. The teeth of the lower jaw in *S. fürthi* form a narrow villiform band, nearly as in *S. ophioscion* and *S. chrysoleuca*, while in *S. oscitans* the dentition is essentially as in *Bairdiella*.

7. Sciæna ensifera, sp. nov. (29316, 29442, 29464, 29506, 29526.)

(Subgenus *Bairdiella* Gill; allied to *Sciæna icistia* J. & G.)

Body compressed, moderately elongate, the back little elevated; snout short, bluntish, not protruding, the profile nearly straight and not very steep to base of first dorsal, along the base of which it is nearly horizontal, thence again declining along base of soft dorsal; ventral outline nearly straight to front of anal, then very sharply angulated, the base of the anal very oblique; caudal peduncle long and slender. Profile depressed above head. Head moderate, compressed with vertical cheeks; preorbital very narrow, narrower than pupil; snout not projecting so far as premaxillaries; premaxillaries in front on the level of lower part of pupil; maxillary extending to opposite middle of pupil. Mouth very oblique, the jaws nearly even in front, the lower very slightly included, the gape $2\frac{1}{3}$ in head. Teeth slender, small, in about 2 series in each jaw, the outer series in the upper jaw enlarged; symphysis of lower jaw with a slight inwardly projecting knob, bearing

teeth a little larger than the others. Chin with 4 distinct pores, the outer pair round. Interorbital space moderate, slightly convex, a little broader than length of snout, 4 in head. Eye very large, considerably longer than snout, $3\frac{3}{4}$ in head. Preopercle with strong teeth, which grow stronger towards the angle, the lowest tooth very strong and directed downwards and forwards. Opercular spines blunt and flattish. Gill-rakers numerous, long and slender, half length of eye.

Scales roughish, extending up on soft portions of vertical fins, covering about one-third of the soft dorsal and more of the anal. Lateral line not strongly curved, becoming straight in front of anal. First dorsal high, its spines slenderer than in *S. armata*, stouter than in *S. icistia;* the second spine short, slender, very stout, half the length of the third, which is $1\frac{3}{4}$ in length of head. Soft dorsal rather high, its longest rays a little less than half head. Caudal subtruncate, the middle and upper rays slightly produced, its length $1\frac{1}{3}$ in head. Distance from front of anal to caudal $3\frac{1}{4}$ in length of body. Abdomen extremely long, its length one-third greater than length of head. Posterior outline of anal fin concave; its second spine very long and strong, scarcely shorter than soft rays, its length $1\frac{1}{3}$ in head, its distance from the vent two-thirds its length. Ventrals long, $1\frac{2}{3}$ in length of head, reaching beyond tips of pectorals, but not quite to vent. Pectorals rather short, $1\frac{2}{3}$ in head.

Head $3\frac{1}{2}$ in length; depth $3\frac{1}{4}$. D. XI–22; A. II, 8; Lat. l. $59\frac{4}{11}$.

Color bluish-gray above and on sides, silvery below; a dark ill defined bluish-gray blotch on upper anterior angle of opercle; mouth yellow within, blackish towards tip of lower jaw. Spinous dorsal translucent, with dark punctulations and a narrow black margin, or sometimes largely blackish; soft dorsal dusky yellow; caudal, and anterior 3 rays of anal brighter yellow; caudal, and membrane between spine and first soft ray of anal with black punctulations; posterior anal rays white; ventrals immaculate; pectorals with upper half of axil and membrane of upper rays internally brownish; the upper rays with a slight yellowish tint externally.

This species is abundant at Panama and Punta Arenas, No. 29506 being from the latter locality. It is apparently the species noticed by Steindachner (Ichth. Beiträge, iii, 1875, 31) under the name of "*Corvina armata.*" The *Bairdiella armata* of Gill is, however, a different species, identical with *Corvina acutirostris* Steind., as we have ascertained by the examination of the typical specimen.

The species of *Sciæna* known from the Pacific coast of tropical America may be distinguished as follows:

a. Lower jaw without canines.

b. Head very broad and depressed, the interorbital space being more than two-sevenths of its length; mouth oblique; teeth small, in narrow bands; preopercle and preorbital usually more or less distinctly cavernous; middle rays of caudal longest; soft parts of vertical fins densely scaly; dorsal spines weak, usually 12 in number; gill-rakers slender, rather long. (*Stelliferus* Stark.)

c. Teeth of lower jaw unequal, not villiform, the inner series rather strong; mouth very large, oblique, the jaws equal, the snout not projecting beyond the premaxillaries, which are on the level of the eye; maxillary extending beyond eye, its length more than half head; interorbital width nearly half head; preopercle with two spines only, the upper directed backward, the lower downward and backward; second anal spine rather strong, 1⅓ in head; lower fins pale. D. XI–I, 22; A. II, 8; Lat. l. 48..... OSCITANS.

cc. Teeth of lower jaw equal, villiform.

d. Mouth terminal, the jaws subequal, the snout scarcely projecting beyond the premaxillaries, which are on the level of lower part of eye; maxillary reaching middle of eye, its length 2⅓ in head; interorbital width less than one-third head; preorbital and preopercle extremely cavernous; preopercle with numerous spines all directed backward; second anal spine not large, 2⅔ in head; lower fins dusky. D. XI–I, 25; A. II, 7; Lat. l. 47.. ERICYMBA.

dd. Mouth subterminal, the lower jaw included, the snout projecting beyond the premaxillaries, which are below the eye; maxillary reaching to behind pupil, 2⅓ in head; interorbital width more than one-third head; bones of side of head scarcely cavernous; preopercle with two spines only, the upper directed backward, the lower downward and forward; second anal spine small, 2¼ in head; lower fins pale. D. XI–I, 23; A. II, 9; Lat. l. 46. FÜRTHII.*

bb. Head not very broad, the interorbital space less than two-sevenths its length; bones of head not cavernous.

e. Gill-rakers extremely short, scarcely longer than posterior nostril; mouth small, more or less inferior, horizontal; lower teeth villiform, in rather broad bands; preopercle with strong teeth, none of them directed downward or forward; anterior profile more or less concave.

f. Caudal fin lanceolate, nearly as long as head; body rather elongate, depth 3⅓ in length; head low, slender, the maxillary reaching middle of eye; snout projecting beyond premaxillaries; second anal spine strong, 1¾ in head; pectorals short, 1⅔ in head; color grayish; anal and ventrals largely black. D. X–I, 22; A. II, 7; Lat. l. 44..... OPHIOSCION.†

ff. Caudal double-truncate or double-concave, much shorter than head.

g. Snout much projecting beyond the premaxillaries; head low, very slender; body rather deep, compressed, the depth 3 in length; second anal spine small, 2⅓ in head; pectoral 1⅓ in head; dorsal spines slender; color grayish; anal and ventrals largely black. D. XI–I, 25; A. II, 8; Lat. l. 49..... IMICEPS.

gg. Snout scarcely projecting beyond the premaxillaries; head not very slender; body robust, its depth 3 in length; second anal spine moderate, 2⅓ in head; color dusky, with blackish stripes along the rows of scales; ventrals and anal largely black. D. X–I, 24; A. II, 7; Lat. l. 47 ..... VERMICULARIS.‡

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* *Corvina* (*Homoprion*) *fürthi* Steindachner, Ichthyol. Beitr. iii, 26, 1875, taf. iii. Panama (*Steind. Gilb.*).

† *Ophioscion typicus* Gill, Proc. Ac. Nat. Sci. Phila. 1863, 164: *Corvina ophioscion* Günther, Fish. Centr. Amer. 1869, 428. Panama (*Gill, Steind. Gthr. Gilb.*).

‡ *Corvina vermicularis* Günther, Fish. Centr. Amer. 1869, 427, pl. lxvii, f. 2. Mazatlan (*Gilb.*); Panama (*Gthr.*).

ee. Gill-rakers not very short, nearly or quite as long as pupil; mouth rather large, terminal or nearly so; anterior profile scarcely concave; caudal rounded or double truncate.

h. Teeth of lower jaw subequal, forming a rather narrow villiform band; preopercle with strong teeth, the lowest one directed downward.

i. Snout bluntish; the head rather stout and broad above; interorbital space broader than eye; dorsal spines rather slender; anal spine moderate, 2 in head; pectorals moderate, $1\frac{1}{5}$ in head; preopercle strongly curved, somewhat V-shaped. Color brassy, with faint dark stripes along the rows of scales; lower fins more or less dusky. D. X–I, 21; A. II, 9; Lat. l. 53.

CHRYSOLEUCA.*

ii. Snout sharp; the head slender, narrow above; interorbital space not broader than eye; dorsal spines strong; anal spine very strong, $1\frac{2}{3}$ in head; pectoral short, $1\frac{1}{3}$ in head; preopercle not strongly curved. Color bluish above, silvery below; lower fins pale. D. X–I, 22; A. II, 8; Lat. l. 52 ..... ARMATA.†

hh. Teeth of lower jaw not villiform, unequal, pointed, in a very narrow band. Color bluish silvery; the lower fins pale. (*Bairdiella* Gill.)

j. Preopercle with strong teeth, the lower tooth largest, directed downward and forward; second anal spine very large.

k. Eye moderate, not longer than snout, 4 to 5 in head; snout not very blunt; dorsal spines very slender; soft dorsal moderate, the longest rays less than half length of head; second anal spine two-thirds length of head; body rather elongate, the depth $3\frac{2}{3}$ in length. D. X–I, 26; A. II, 8; Lat. l. 54.

ICISTIA.

kk. Eye very large, longer than snout, 3 to 4 in head; snout very blunt; dorsal spines comparatively stiff; soft dorsal high, its longest rays about half head; second anal spine very large, four-fifths head; body not very elongate, the depth about $3\frac{1}{2}$ in length. D. X–I, 23; A. II, 8; Lat. l. 57 ..... ENSIFERA.

jj. Preopercle with fine uniform teeth, none of them directed downward; second anal spine small, $2\frac{2}{3}$ in head; eye very large, longer than snout, 3 to 4 in head; dorsal spines rather slender; body deep, depth $2\frac{2}{3}$ in length. D. XI–I, 26; A. II, 10; Lat. l. 50 ..... MACROPS.‡

aa. Lower jaw with two slender canines in front, the other teeth unequal, not villiform, in few series (*Odontoscion* Gill); mouth large, oblique, lower jaw slightly projecting; preopercle with a few rather strong teeth, the lower one largest and directed downwards; snout rather pointed; eye large, longer than snout; dorsal spines very slender; anal very small, its spine small, 3 in head; body rather elongate, depth $3\frac{2}{3}$ in length. Color silvery, bluish above; lower fins pale. D. X–I, 23; A. II, 8; Lat. l. 58.

ARCHIDIUM.

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* *Corvina chrysoleuca* Günther, Fish. Centr. Amer. 1869, 427, pl. lxvii, f. 1: ? *Sciana aluta* Jor. & Gilb. Proc. U. S. Nat. Mus. iv, 1881, 332; probably the same species, but with D. X–I, 19; Lat. l. 45, etc. La Union (Nichols Coll.); Panama (*Gthr. Gilb.*).

† *Bairdiella armata* Gill, Proc. Ac. Nat. Sci. Phila. 1863, 164: *Corvina* (*Homoprion*) *acutirostris*, Steindachner, Ichthyol. Beitr. iii, 28, 1875, taf. iv. Panama (*Gill*; *Steind. Gilb.*).

‡ *Corvina macrops* Steindachner, Ichthyol. Beitr. iii, 1875, 24, taf. ii. Panama (*Steind.*).

8. **Odontoscion archidium**, sp. nov. (29266, 29480, 29518.)

Head and body rather elongate, considerably compressed; back not elevated, the snout somewhat gibbous, the profile depressed above the eyes.

Mouth very large, terminal, oblique, the maxillary reaching vertical from posterior margin of pupil; jaws subequal; premaxillaries in front on the level of lower edge of pupil; symphysis of lower jaw with an oblong knob, which projects inwards and upwards; on this are two series of teeth, three in each series, the inner pair being canines of moderate size, larger than any of the other teeth, but much smaller and slenderer than the canines in *Cynoscion*. Both jaws without villiform teeth; upper jaw with two series of slender pointed teeth, the outer series enlarged. Lower jaw laterally with a single series of teeth similar to those of the outer series of upper jaw, but larger; those in the middle of the jaw largest.

Diameter of eye about equal to length of snout, or to interorbital width, and $4\frac{1}{2}$ times in length of head. Length of maxillary $2\frac{1}{4}$ in head.

Gill-rakers long and slender, $6+13$ in number. Pseudobranchiæ well developed. Posterior nostril a narrow oblong vertical slit.

Posterior margin of preopercle inclined downward and backward, both margins convex and with the angle broadly rounded. Both margins with weak distinct serrations; posterior border with two or three stronger teeth next the angle directed backwards, the angle with one robust flattish spine directed more or less vertically downwards.

Spinous dorsal with very weak, flexible spines, the third the longest and about half length of head; soft dorsal moderate, the longest ray shorter than the dorsal spines but more than one-third length of head. Caudal fin subtruncate or slightly emarginate. Anal fin very small, posteriorly inserted, its base but little oblique; length of base about equal to length of snout; second anal spine moderate, shorter than the first soft ray; much stronger than the dorsal spines and inflexible, its length about equal to snout and half of eye, 3 in head. Distance from front of anal to middle of base of caudal slightly more than one-fourth the length of the body. Distance from vent to front of anal about equal to length of base of anal.

Pectoral short, not reaching tips of ventrals, its length $1\frac{3}{4}$ in head. Ventrals reaching half way to front of anal, not nearly to vent. Membranes of soft parts of vertical fins with series of scales extending more than half way to the tips. Lateral line scarcely arched, becoming straight opposite front of soft dorsal.

Head 3 times in length; depth $3\frac{1}{3}$. Dorsal rays XI, 24; Anal II, 8; Lateral line 50 (series of scales); 52 pores.

Color lustrous bluish-gray above, silvery below; middle of sides with indistinct lengthwise streaks formed by clusters of dark dots in the centers of the scales. Snout and tip of lower jaw blackish; a dark blotch on opercle above; sides of head bright silvery; fins light straw

color; upper half of pectorals dusky; spinous dorsal finely speckled with black; upper half of axil brown. Peritoneum pale; lining of opercle black above. Iris bright yellow, dusky above.

This species is known to us from three specimens, each about 7 inches in length, taken in the Bay of Panama. It seems to be related to *Corvina dentex* C. & V. and thus to belong to the group called *Odontoscion* by Professor Gill. Its affinities with *Bairdiella* are evident, the development of small canines in the lower jaw being the only character distinguishing *Odontoscion* from *Bairdiella*.

9. **Cynoscion phoxocephalum**, sp. nov. (29296, 29339, 29389, 29724.)
(Subgenus *Atractoscion* Gill.)

Body not very elongate, fusiform, little compressed, the greatest thickness nearly two-thirds the greatest depth. Back scarcely elevated nor compressed, the profile from the snout to the front of the dorsal nearly straight.

Head conical, little compressed, pointed in profile, tapering with much regularity toward the tip of the projecting lower jaw; length of mandible more than half that of head. Mouth large, very oblique, the premaxillary in front on the level of the upper part of the orbit, the broad maxillary extending to below the posterior margin of the eye, 2 in head.

Teeth in narrow, cardiform bands in each jaw, the bands composed of about 2 series in front, growing narrow laterally, and finally forming a single series. Teeth subequal, with the exception of about two pairs in the front of the upper jaw, the posterior pair being developed as small canines directed inward and backward. In the smaller specimens the canines are proportionately larger than in the adult, but in all they are smaller than is usual in *Cynoscion*.

Eye rather small, $7\frac{1}{2}$ in head, a little less than half the length of the snout, a little more than half the breadth of the evenly convex interorbital space, which is $3\frac{2}{3}$ in head. Gill-rakers few, thickish, and very short, shorter than the pupil. Pseudobranchiæ quite small.

Scales of lower part of cheeks enlarged, imbedded, covered with silvery skin. Scales above eyes on nape and on border of preopercle much reduced in size. Preopercle, as in all species of this genus, entire, with a broad membranaceous border.

Scales on body small and smooth. Lateral line scarcely arched in front, becoming straight opposite front of anal.

Dorsal fins entirely separate, the spines of the first dorsal slender. Second spine shorter than third and fourth, which are considerably elevated, $1\frac{3}{4}$ in length of head in the young, $2\frac{1}{3}$ in the adult. Second dorsal of moderate height, enveloped in lax scaleless skin, which is thickened at the base of the fin; longest rays a little more than one-third length of head. Anal rather long and low, its longest rays about equal to the length of the base, and a little more than one-third length of head. Anal spines very small and weak, wholly enveloped in the skin and not visi-

ble. Anal fin nearly coterminous with the dorsal, its rays similarly enveloped in loose skin. Caudal fin moderate, thickish and scaly at base, lunate, its lobes equal, the middle rays $1\frac{2}{3}$ in length of head. Ventrals short, about half length of head, reaching about one-third the distance to the vent. Pectorals short, not reaching tips of ventrals, 2 in head. Distance from vent to base of caudal about two-fifths its distance from snout.

Head $3\frac{1}{3}$ in length; depth $4\frac{1}{3}$. D. IX–I, 21; A. II, 10; Lat. l. 90 (series of scales, the number of pores in the lateral line somewhat less); 17 scales in an oblique series from first dorsal spine to lateral line.

Color in life, dark above with strong bright reflections of purplish-brown; silvery below, the lower part of the caudal peduncle golden yellow. Middle of sides noticeably punctulate with brown dots; inside of mouth deep orange yellow; lining of opercle black. Dorsal and caudal fins dusky whitish, with more or less of dark edging; lower rays of caudal yellowish; fins otherwise translucent, unmarked. Axil of pectoral light brownish above. The silvery color of the sides of the head and the bright reflections on its upper surface are very conspicuous, more so than in any other species of the genus.

Four specimens, the largest (No. 29296) $16\frac{1}{2}$ inches in length, were obtained at Panama. This species is readily distinguishable from all others of the genus found in the Pacific Ocean, by the peculiar, tapering head.

The species of *Cynoscion* known from the Pacific coast of tropical America may be compared as follows:

a. Second dorsal and anal scaleless.
  b. Canines of upper jaw large, 2 (or 1) in number; membranes of soft dorsal not thickened.
    c. Back and sides with conspicuous dark reticulations; soft dorsal with 25 to 28 rays; maxillary not quite reaching posterior border of eye; caudal double-truncate; pectorals about reaching tips of ventrals, rather more than half head; scales 9–73–16; 60 pores in lateral line ..... RETICULATUM.*
  cc. Back and sides nearly plain grayish-silvery; soft dorsal with 20 to 23 rays.
    d. Caudal fin double-concave, the middle rays more or less produced; anal rays II, 7 to II, 9.
      e. Pectorals reaching nearly or quite to tips of ventrals, their length more than half head.
        f. Scales very small (12–86–*x*); about 70 pores in the lateral line; head rather long and pointed; maxillary a little less than half head, reaching just past eye; lateral line becoming straight nearly opposite vent ..... XANTHULUM.
        ff. Scales moderate (8–66–18); 63 pores in lateral line; head large, bluntish; maxillary nearly half head, reaching well past eye; lateral line becoming straight at a point considerably in advance of vent ..... ALBUM.†

* *Otolithus reticulatus* Günther, Proc. Zool. Soc. Lond. 1864, 149. Mazatlan (*Gilb.*); Acapulco (*Nichols coll.*); San José de Guatemala (*Gthr.*); Chiapam (*Gthr.*); Panama (*Gilb.*).

† *Otolithus albus* Günther, Proc. Zool. Soc. Lond. 1864, 149. Chiapam (*Gthr.*); Panama (*Gthr. Steind. Gilb.*).

ee. Pectorals reaching little past middle of ventrals, their length not more than half head; body elongate; mouth oblique, the maxillary extending to below its posterior margin; lateral line becoming straight under front of second dorsal; scales 10-73-17; about 60 pores in lateral line ..... STOLZMANNI.*

dd. Caudal fin lunate, the middle rays shortest; anal rays II, 10; pectorals short, not reaching to tips of ventrals; scales 90; lateral line with about 75 tubes; maxillary extending beyond pupil ..... PARVIPINNE.†

bb. Canines little developed, usually 4 in number when present. (*Atractoscion* Gill.)

g. Pectoral moderate, more than half head; head pointed, compressed, $3\frac{2}{3}$ in length; gill-rakers moderate; scales very small (13–95–*x*), those on head little embedded; canines obsolete; caudal lunate, its middle rays less than half head. D. X–I, 22; A. II, 10. Color grayish; lower fins dusky; inside of opercle not black. Size very large ..... NOBILE.‡

gg. Pectorals short, not more than half head; second dorsal enveloped in lax, naked skin, thickened at base; head regularly conical, pointed, tapering, scarcely compressed, $3\frac{1}{3}$ in length; gill-rakers very short; scales very small (14–90–*x*), those on the head largely imbedded; canines small; lateral line little arched; caudal lunate, its middle rays more than half head. D. IX–I, 21; A. II, 10. Color silvery, with bright reflections; lower fins pale; lining of opercle black ..... PHOXOCEPHALUM.

aa. Second dorsal and anal densely covered with small scales; coloration grayish-silvery; canines well developed; sides of lower jaw with a single series of teeth.

h. Caudal lunate; dorsal rays IX–I, 23; A. II, 10; Lat. l. about 65; maxillary reaching a little beyond eye; pectorals more than half length of head, reaching beyond tips of ventrals; lateral line becoming straight in front of vent. OTHONOPTERUM.

hh. Caudal rhombic, the middle rays produced; D. VIII–I, 21; A. II, 10; Lat. l. about 70; maxillary reaching a little beyond eye; pectoral shortish, scarcely more than half length of head; lateral line becoming straight opposite front of anal ..... SQUAMIPINNE.§

10. **Isopisthus remifer**, sp. nov. (29169, (3 spec.); 29312, 29324; 29336; 29429.)

Head $3\frac{1}{4}$ ($3\frac{3}{4}$ in total); depth $4\frac{1}{5}$ ($4\frac{3}{4}$); length (29312) 11 inches. D. VIII–I, 20; A. II, 19; scales 15–73–16; about 55 scales pierced by the lateral line.

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* *Otolithus stolzmanni* Steindachner, Neue & Seltene Fische aus den K. K. Zoöl. Museen Wien. &c. 1879, 35, taf. ii, f. 1. Panama (*Gilb.*); Tumbez (*Steind.*).

† *Cynoscion parvipinnis* Ayres, Proc. Cal. Ac. Nat. Sci. 1861, 156: *Otolithus magdalenæ* Steindachner, Ichth. Beiträge, iii, 1875. San Pedro (*Jor. & Gilb.*); San Diego (*Jor. & Gilb.*); Coast of Lower California (*Ayres*); Magdalena Bay (*Steind.*); Gulf of California (*Nichols coll.*).

‡ *Johnius nobilis* Ayres, Proc. Cal. Ac. Nat. Sci. 1860, 78: *Otolithus californiensis*, Steind. Ichth. Beitr. iii, 31, 1875. San Francisco to Magdalena Bay.

§ *Otolithus squamipinnis* Günther, Proc. Zoöl. Soc. Lond. 1866, 601. La Union (*Nichols coll.*); Panama (*Gthr. Steind.*).

Body moderately elongate, compressed, the back not elevated; head compressed; snout rather short, not prominent; anterior profile slowly rising from snout to front of dorsal. Premaxillaries extending beyond front of snout, anteriorly on the level of the upper part of the pupil. Mouth large, very oblique, the maxillary extending to below the middle of the eye, its length $2\frac{1}{3}$ in head. Lower jaw strongly projecting at tip. Chin without pores.

Front of premaxillaries with a long, sharp, curved canine on each side (one of these often smaller or absent); sides of upper jaw with smaller teeth, wide-set, mostly in one row. Lower jaw with about two series of small, slender teeth in front; laterally with a single series of small teeth, besides three to six large canines, much smaller than the canines of the upper jaw.

Preorbital narrow, not wider than the pupil. Eye large, $4\frac{1}{2}$ in head, slightly shorter than snout, which is about equal to interorbital width. Preopercle with a membranaceous flap at its angle, which is striate and slightly fringed at its edge. Gill-rakers rather long and slender, few in number. Pseudobranchiæ well developed. Nostrils small, the posterior vertically oblong.

Scales small, nearly smooth, deciduous. Dorsal and anal fins closely covered with small scales. Lateral line little arched, becoming straight behind vent. First dorsal small, its spines slender, the highest $2\frac{1}{2}$ in length of head. First spine minute or obsolete, the second not much shorter than third. Space between dorsal fins about equal to diameter of eye, $3\frac{1}{2}$ in head. Soft dorsal moderate, its longest ray a little less than one-third length of head. Caudal shortish, slightly double-concave, its middle rays about half length of head. Base of anal two-thirds length of head, its spines rudimentary. Ventrals half length of head, reaching half way to vent, which is close in front of anal. Pectorals reaching considerably beyond tips of ventrals, their length $1\frac{1}{4}$ to $1\frac{1}{3}$ in head, $4\frac{1}{3}$ to $4\frac{1}{2}$ in body. Flesh comparatively soft.

Color in life: Bluish gray above; grayish silvery below; top of snout and tip of lower jaw blackish; inside of mouth yellow, with black on lower lip within; lining of opercles black, bordered with pale orange. Dorsals, caudal, and pectorals with fine black punctulations; the ground color in all except the spinous dorsal faintly yellowish. Anal white, the anterior part and the tips of most of the rays yellowish, punctate with black. Ventrals white, immaculate. A dark blotch behind orbit and another on upper part of opercle. Axil brown above, the color extending on the upper rays of the pectoral within.

This species seems to be rather common at Panama, where numerous specimens were obtained. It is extremely close to *I. affinis* Steind. from Porto Alegre, Brazil, and were it not for the considerably longer pectoral, we should consider it identical with the latter species. *Isopisthus parvipinnis* (C. & V.) Gill, from Surinam, is insufficiently described, but seems to be nearer *I. affinis*, if not identical with it.

11. **Serranus lamprurus**, sp. nov. (29651.)

Subgenus *Plectropoma* Cuvier; allied to *Serranus chlorurus* C. & V. (*Plectropoma chlorurum* C. & V.), but with considerably larger scales.

Body short and deep, compressed, the back elevated, the ventral outline from lower jaw to front of anal, little arched; profile convex from dorsal to occiput, thence concave above eye, the snout low and acute in profile. Mouth large; maxillary about half length of head, reaching to below the middle of the eye, the premaxillary in front rather below the level of the lower edge of the eye; preorbital narrow; jaws subequal, the lower slightly included; teeth strong, the anterior canines stronger than those of the sides of the jaws, about 4 in the upper jaw and 6 in the lower; teeth all fixed. Cheeks with 5 rows of scales; top of head and both jaws scaleless. Eye large, about equal to snout and broader than interorbital space, about $3\frac{1}{2}$ in head (doubtless smaller in adults). Vertical limb of preopercle nearly straight, the teeth growing larger downwards; angle and lower limb with about 9 strong radiating teeth, those nearest the angle largest, the anterior directed more and more forwards. Opercle with two flat points. Gill-rakers moderate, slender, nearly as long as pupil. Dorsal spines strong, the fourth the highest, about equal to soft rays and $2\frac{1}{3}$ in head; the last spine considerably shorter than soft rays. Caudal emarginate, $1\frac{2}{3}$ in head, the middle rays little shorter than the outer. Anal spines strong, the second longer and stronger than the third, $2\frac{2}{3}$ in head. Ventrals long, $1\frac{2}{5}$ in head, nearly reaching anal. Pectorals about reaching anal, $1\frac{1}{3}$ in head. Scales above lateral line in series parallel to lateral line. Head $2\frac{3}{5}$ in length; depth $2\frac{1}{4}$. D. X, 13; A. III, 8; scales 6–46–13.

Color black with violet luster; faint pale streaks formed by paler spots along rows of scales on lower part of body. Entire caudal fin abruptly translucent; pectoral nearly colorless; tips of spines of dorsal and anal, and terminal portions of soft rays, abruptly whitish. Ventrals black.

A single specimen, three inches in length, was taken in a tide-pool in Panama Bay. It would be a species of "*Hypoplectrus*" in Professor Gill's arrangement of the Serranoids.

12. **Diabasis steindachneri**, sp.nov. (29305, 29387 from Panama, 28172, 29226, 29634, 29759, 29778, 29795 from Mazatlan.)

(*Hæmulon caudimacula* Steindachner, Ichthyol. Beiträge, iii, 15 (Acapulco, Rio Janeiro, Rio Grande do Sul, Maranhaõ, not of Cuv. & Val., v, 236, 1830 = *Diabasis parræ* Desm.)*

* The *Hæmulon caudimacula* is imperfectly described by Cuvier and Valenciennes. We are indebted to Dr. H. E. Sauvage, of the Museum d'Histoire Naturelle of Paris, for the following important information concerning the species:

There are in the Museum of Paris three specimens of *Hæmulon caudimacula*, viz, from Brazil by Delalande, from Bahia by Castelnau, and from Cuba by Desmarest. The diagnosis of this latter specimen, the type of the species and the type of *Diabasis parræ* Desmarest, is as follows:

D. XI, I, 15; A. III, 7; Lat. l. 49.

Height of the body equal nearly to the length of the head, and $3\frac{1}{2}$ in the total

Head 3 ($3\frac{2}{3}$ with caudal); depth $2\frac{5}{6}$ ($3\frac{3}{5}$); length (29387) $7\frac{1}{2}$ inches. D. XII, 16; A. III, 8; scales 7–50–14.

Body oblong, moderately compressed, the back somewhat elevated; the profile from the snout to the base of the dorsal rather steep and straight or slightly convex. Snout pointed, of moderate length, a little more than one-third of length of head. Ventral outline little curved. Caudal peduncle nearly twice as long as deep, three-fifths length of head.

Head rather long and pointed. Mouth large, little oblique, the premaxillary below lower border of eye; the lower jaw included; the maxillary 2 in head, reaching to opposite middle of pupil, its posterior portion extending behind the preorbital sheath. Teeth strong, in moderate bands, the outer series enlarged, especially in the upper jaw, and on the sides of the lower jaw. Chin with a large pit and two pores. Eye rather large, 4 in head, shorter than snout, which is 1 more than to the width of the flattish interorbital space; about half wider than the moderate preorbital.

Preopercle sharply serrate, its upright limb nearly straight. Gill-rakers short and weak, about 15 on lower part of arch.

Scales moderate, those above lateral line in very oblique series, becoming horizontal on the caudal peduncle; those below it in horizontal series. Vertical fins well scaled, the scaly sheaths of dorsal and anal well developed. Scales on breast small. Dorsal fin rather high, the spines strong, the fourth or longest $2\frac{1}{4}$ in head, about one-third longer than the soft rays. Caudal short, moderately forked, the upper lobe slightly the longest, two-thirds head. Second anal spine strong, $2\frac{2}{5}$ in head; much longer than the third spine, which is shorter than the soft rays. Soft rays of anal high, the first soft ray when depressed reaching almost to tip of last ray; much beyond the base of the last ray. Ventral fins four-sevenths length of head, not reaching tips of pectorals, which are about three-fourths length of head.

Color in life, light olive brown, silvery below, the edges of the scales of back with brilliant bluish luster. Each scale on back and sides with a median silvery spot (much larger than the spots in *D. flavigutattus*), these forming very distinct streaks, having the direction of the

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length; snout pointed, a little longer than the diameter of the eye, which is $3\frac{3}{4}$ in head, and equal to the distance between the angle of the operculum and the limb of the preoperculum. The upper maxillary extends to the vertical from the anterior margin of the eye. The posterior limb of the preoperculum is slightly emarginate and minutely denticulated, the denticulations of the angles not stronger than the others. Dorsal fin notched; spines moderately strong, the fourth longest, $2\frac{1}{3}$ in length of head. Soft dorsal, caudal, and anal fins thickly enveloped in scales. Caudal fin little notched. Second anal spine a little longer than third, as long as the longest dorsal spine. Scales between pectoral fin and lateral line not larger than the others.

Color yellowish with numerous (18) oblique brownish streaks on the side of the body; anal and ventral fins blackish; some irregular brownish spots on the caudal.

Total length *m.* 0, 130; head 0, 039; eye 0, 010; snout 0, 013; second anal spine 0, 017; fourth dorsal spine 0, 017; depth of body 0, 037.

rows of scales. Head brownish, unspotted. A large, distinct, round blackish blotch on end of caudal peduncle and base of caudal fin, more distinct than in other species known to us. A distinct bluish black vertical bar on lower anterior part of opercle, partly concealed by angle of preopercle. Fins all bright yellowish; ventrals and anal not dark. Peritoneum dusky.

This small species was found to be rather rare at Mazatlan, and comparatively abundant at Panama.

Dr. Steindachner has identified this species with *Hæmulon caudimacula* C. and V., remarking: "Ich verglich die bei Acapulco gesammelten Exemplare auf sorgfältigste mit jenen, welche das Wiener Museum aus der Bucht von Rio Janeiro, von Rio Grande do Sul sowie von Maranhaõ besitzt, und bin nicht in Stande, zwischen diesen ein Artunterschied zu entdecken."

Whether the Brazilian specimens referred to really belong to the present species or not, it is evident that the original *Hæmulon caudimacula* is a very different species.

The species of *Diabasis* found on the Pacific coast of Tropical America may be compared as follows:

a. Scales above lateral line arranged in very oblique rows.
  b. Spots on scales black or blackish.
    c. Snout long and protruding, forming more than two-fifths length of head; preorbital very deep, wider than eye; sides with dark vertical bars; sides of head spotted; size large ..... SEXFASCIATUS.*
    cc. Snout short and bluntish, about one-fourth length of head; preorbital about as wide as eye; sides not barred; head unspotted ..... SCUDDERI.†
  bb. Spots on scales pale-bluish or grayish.
    d. Mouth large, nearly horizontal, the maxillary extending to opposite middle of eye, beyond preorbital sheath; head long, 3 in length; gill-rakers short and weak; anal fin rather high, the first soft rays when depressed extending beyond the base of the fin; spots silvery, comparatively large ..... STEINDACHNERI.
    dd. Mouth small, oblique, the maxillary reaching pupil, not beyond preorbital sheath; head short, 3⅔ in length; gill-rakers comparatively long and slender; anal fin low, the first soft ray when depressed not reaching to base of last ray; spots bluish, small, stellate.
      FLAVIGUTTATUS.‡

* *Hæmulon sexfasciatus* Gill, Proc. Ac. Nat. Sci. Phila. 1862, 254: *Hæmulon maculosum* Peters, Berlin Monatsber., 1869 705. Cape San Lucas (*Gill*); Mazatlan (*Gilb. Peters*); Panama (*Steind. Gilb.*).

† *Hæmulon scudderi* Gill, Proc. Ac. Nat. Sci. Phila., 1862, 253: *Hæmulon brevirostrum* Günther, Fish. Centr. Amer. 1866, 418: *Hæmulon undecimale* Steindachner, Ichthyol. Beitr. iii, 11, 1875. (Cape San Lucas (*Gill*); Mazatlan (*Steind. Gilb.*); Acapulco (*Steind.*); Panama (*Günther, Steind. Gilb.*). The dorsal spines in this species are normally 11.

‡ *Hæmulon flaviguttatus* Gill, Proc. Ac. Nat. Sci. Phila. 1862, 254: *Hæmulon margaritiferum* Günther, Proc. Zool. Soc. Lond. 1864, 147. (Cape San Lucas (*Gill*); Mazatlan (*Steind. Gilb.*); Acapulco (*Steind.*); Altata (*Steind.*); Panama (*Gthr. Steind. Gilb.*).

aa. Scales above lateral line in horizontal rows parallel with the lateral line; body elliptical; mouth small, little oblique; sides with alternate stripes of dark brown and light grayish.....MACULICAUDA.*

13. **Xenichthys xenops**, sp. nov. (29173 (eighteen specimens), 29513.)

Allied to *X. xanti.*

Form elliptical, the body comparatively deep, compressed, the back somewhat elevated; profile nearly straight from snout to base of dorsal. Head subconic, flattish above, not strongly compressed; the temporal region prominent. Post-temporal, interorbital, and suborbital regions somewhat cavernous, yielding to the touch. Nuchal region slightly carinate.

Mouth terminal, very oblique, the lower jaw strongly projecting, its tip entering the upper profile of head. Preorbital rather narrow, its least width less than half the diameter of the pupil. Teeth small and feeble, in narrow bands in both jaws; a few on vomer, none on palatines or tongue. Nostrils similar, near together, oblong, more than twice as long as broad (nearly round in *X. californiensis.*) Preorbital region, upper jaw, and tip of lower jaw naked; rest of head scaly. Edge of preorbital entire. Eye extremely large, half longer than snout, which is somewhat longer than the width of the flat interorbital space; diameter of eye 3 in length of head. Preopercle produced and membranaceous at its angle, its vertical limb with weak, sharp teeth. Gill-rakers moderate, about half diameter of pupil.

Scales moderate, thin, somewhat ctenoid, those of the breast like the others; scales on breast and back somewhat reduced.

Dorsal spines high, flexible, the third highest, as long as snout and eye, or $1\frac{2}{3}$ in head, $5\frac{1}{3}$ in length of body; tenth dorsal spine very low; eleventh and twelfth a little higher; soft dorsal long and low, its highest rays less than diameter of orbit; its base three-fourths length of head; slightly longer than base of soft dorsal, equal to base of anal. Anal spines small, graduated, the third two-thirds height of the soft rays. Caudal moderately and equally forked, the middle rays two-thirds length of outer; length of the fin more than length of snout and eye. Pectoral short, not reaching nearly to vent; a little longer than snout and eye, or $1\frac{1}{2}$ in head. Ventrals not nearly reaching vent, $1\frac{3}{4}$ in head, their accessory scale well developed. Vertical fins with well-developed sheaths of scales; anal entirely scaly; soft dorsal, pectorals, and ventrals mostly covered with scales; caudal partly scaled.

Head 3 in length; depth 3. D. XI, I, 18; A. III, 17; scales 10–54–14.

Coloration in life: Back bluish gray, below silvery; upper part of sides with seven or eight longitudinal, narrow, yellowish-brown streaks, some of which are continued very faintly on the head; snout blackish above, yellowish on sides; mouth light yellow within, with tip of tongue

* *Orthostœchus maculicauda* Gill, Proc. Ac. Nat. Sci. Phila. 1862, 255: *Hæmulon mazatlanum* Steind. Ichth. Notizen VIII, 12, taf. vi, 1869. Cape San Lucas (*Gill*); Mazatlan (*Steind.*); Acapulco (*Steind.*); Panama (*Gilb.*).

and membrane of lower jaw blackish anteriorly. Eye with a dusky yellowish streak surrounding the iris. Spinous dorsal yellowish below, dusky towards the margin; other vertical fins yellowish, with some scattered black points and with narrow black margins. Pectorals yellowish, the membrane with series of dark points between the rays. Ventrals white, with a dusky yellow blotch on the outer half of outer rays.

Numerous specimens, all about ten inches in length, were obtained in the Bay of Panama.

This species is a member of the typical section of the genus *Xenichthys*, which is characterized by the length of the soft dorsal and anal, these being much longer than the spinous part. To this section also belong *X. xanti* Gill and *X. agassizii* Steind. The two remaining species, now known (*X. californiensis* Steind. and *X. xenurus* J. & G.), have the soft dorsal and anal not longer than the spinous dorsal.

The species of *Xenichthys* may be distinguished by the following analysis:

a. Soft dorsal much longer than spinous dorsal, of 14 to 18 rays; anal elongate, with 16 to 18 soft rays; form elliptical, the depths about equal to length of head. Caudal lunate.

b. Scales of the lateral line larger than the others; dorsal rays XII, 14; lat. l. 50; eye moderate, 3 in head, the maxillary not reaching its front; pectoral short, little longer than ventrals, about half length of head. Pale, with two purplish longitudinal stripes; an obscure spot at base of caudal ..... XANTI.*

bb. Scales of lateral line like the others.

c. Eye very large, $2\frac{1}{3}$ in head, the maxillary reaching beyond its front; pectoral moderate, $1\frac{2}{3}$ in head, considerably longer than ventrals; dorsal rays XI, 18; lat. l. 54. Color silvery, with several faint longitudinal dark streaks; lower fins with dusky points ..... XENOPS.

cc. Eye rather large, $3\frac{1}{4}$ in head; pectoral very long, scarcely shorter than head; dorsal rays XII, 18; lat. l. 58. Color silvery, bluish above, without stripes ..... AGASSIZII.†

aa. Soft dorsal shorter than spinous dorsal of 10 or 11 rays; anal short, of 10 or 11 soft rays.

d. Caudal fin lunate, the middle rays more than half length of outer; body rather elongate, the depth ($3\frac{1}{2}$) equal to length of head; eye moderate, $3\frac{1}{2}$ in head; dorsal spines moderate, the longest three-fifths head; pectorals rather long, three-fourths head; dorsal rays X, 12; lat. l. 52. Color silvery, bluish above, with several longitudinal dark stripes. CALIFORNIENSIS.‡

dd. Caudal fin deeply forked, the middle rays scarcely one-third length of the outer; body not elongate, the depth ($2\frac{3}{8}$) much more than length of head; eye very large, $2\frac{3}{8}$ in head; dorsal spines very high, the longest two-thirds head; pectorals short, two-fifths head; dorsal rays X, 11; lat. l. 51. Color olivaceous above, silvery below, unstriped. XENURUS.

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* *Xenichthys xanti* Gill, Proc. Ac. Nat. Sci. Phila. 1863, 82. Cape San Lucas (*Gill*).

† *Xenichthys agassizii* Steindachner, Ichthyol. Beiträge, iii, 6, 1875. Galapagos Islands (*Steind.*).

‡ *Xenichthys californiensis* Steindachner, Ichth. Beitr. iii, 3, 1875. San Diego (*Steindachner*); Cerros Island (*Streets*; *Nichols coll.*).

14. **Pimelepterus ocyurus**, sp. nov. (29395, 29397, 29725.)

Body oblong-elliptical, much less compressed and elevated than in related species; both dorsal and ventral outlines regularly and nearly equally curved; frontal region little gibbous, the depression below it little marked and the snout scarcely blunt.

Mouth small, terminal, the lower jaw slightly included; maxillary not reaching front of eye. Incisor teeth very small, about 30 in the upper jaw lanceolate, each with a very small horizontal process, shorter than the tooth. Behind them a band of scarcely evident asperities; patches of similar asperities on vomer and palatines. Eye very large, nearly as long as snout, its diameter nearly one-half interorbital width and one-fourth length of head. Preopercle produced and rounded at angle, its margin weakly serrulate. Gill-membranes united straight across breast, free from the isthmus, their free border under posterior part of eye. Gill-rakers small and short; pseudobranchiæ present. Head more completely scaled than in *P. bosci*, the naked areas similar, but more restricted. Scales striated and rugose, but scarcely ctenoid; much smoother than in *P. bosci;* those on middle of sides largest; those on breast not much reduced in size. Soft dorsal and anal completely covered with scales, the pectorals and caudal nearly so. Dorsal spines low, the longest $3\frac{1}{4}$ in head; the base of the fin nearly equal to that of the soft dorsal or the anal. Soft dorsal very low, its last rays longest, its middle rays not so long as the eye. Caudal extremely long, deeply forked, the lobes falcate, the upper rays more than four times the length of the middle rays, and equal to the greatest depth of the body. Anal long and low, its base greater than length of head, its last ray longest, its middle rays shorter than eye. Anal spines small, graduated. Ventrals short, well behind pectorals, nearly half length of head, and reaching half way to front of anal. Pectorals short, a little more than half head.

Head $3\frac{1}{5}$ in length; depth $2\frac{4}{5}$. D. XI, 13; A. III, 14; scales 12–78–20 (rows).

Color in life: Back and sides above light olive brown, becoming yellowish olive below; belly and lower part of sides white. Each side of back with a very distinct dark-blue stripe, commencing a little in front of origin of dorsal and running to upper lobe of caudal fin; it gradually increases in width backwards to caudal peduncle, along which it is suddenly narrowed. A small blue spot on median line between the orbits, a broad blue stripe from snout through eye to suprascapula; a second from snout through lower margin of orbit to opercle, where it is abruptly expanded; lores golden; a broad golden stripe behind angle of mouth, not reaching preopercular margin. A broad dark-blue stripe from above base of pectorals straight to base of median caudal rays. Below this is a narrower golden stripe. Lower part of sides with indistinct longitudinal brownish streaks along the margins of the series of scales. Vertical fins golden yellow, caudal narrowly margined with black. Pec-

torals brown within, the outer side silvery with yellow tinge. Ventrals yellow on inner margins, silvery on the outer. Roof of mouth and tongue bright white.

This species occasionally appears in large numbers in the market of Panama, where several specimens were obtained.

The type of the present description (No. 29395) is 16 inches in length.

The species of *Pimelepterus* known from the Pacific Coast of tropical America may be thus distinguished:

a. Incisor teeth well developed, each with a conspicuous horizontal process or root; caudal fin moderate, about as long as head, the outer rays not 3 times length of middle rays; junction of gill-membranes forming an angle.

b. Body broad-ovate, the depth 2 to 2¼ in length; profile of snout concave; interocular space gibbous; fins low, the longest dorsal spines less than half head; scales not small, about 10–57–17. Color dusky, with light and dark stripes along the rows of scales; fins mostly dark.....ANALOGUS.*

bb. Body oblong-elliptical, the depth 2⅓ in length; profile of snout not concave, the interocular space little gibbous; fins rather high, the longest dorsal spine half head; scales rather small, 12–67–22. Color chiefly yellow, not distinctly striped; fins pale.....LUTESCENS.†

aa. Incisor teeth small, with inconspicuous roots; caudal much longer than head, the lobes falcate, the outer 5 times length of middle rays; gill-membranes not forming an angle at junction; form rather slender, the depth 2⅔ in length; profile of snout scarcely concave; interocular space little gibbous; fins low, the highest dorsal spine less than one-third head; scales small, 10–78–18. Color olivaceous, with blue and golden spots and stripes; fins mostly yellow. OCYURUS.

15. **Gerres aureolus**, sp. nov. (29487.)

Body ovate, much compressed, the back elevated, the outlines nearly regular; outline along base of anal very oblique; caudal peduncle very short and deep, tapering regularly to base of tail; snout rather pointed, projecting, the interorbital area strongly depressed. Maxillary long, reaching to a point midway between front and middle of pupil, the exposed portion narrowly oblong, its width about two-fifths its length; teeth slender, in narrow bands; groove on top of head for premaxillaries, scaleless, triangular, reaching a point opposite middle of eye, its width in front two-thirds its length. Eye very large, its diameter greater than snout or than interorbital width, 3¼ in head. Preopercle with the angle produced, the margin sharply and finely serrated. Gill-rakers very short, not one-third diameter of pupil. Scales moderate, in about 4 rows on the cheek; lateral line running high, but little arched, much above axis of body even on caudal peduncle.

Dorsal spines slender, but little flexible, the second scarcely stronger than the others, about as long as the third, half as long as the head. Dorsal fins separate, notched to the base, the upper outline of spinous

**Pimelepterus analogus* Gill, Proc. Ac. Nat. Sci. Phila. 1862, 245: *Pimelepterus elegans* Peters, Berliner Monatsber. 1869, 707. Cape San Lucas (*Gill.*); Mazatlan (*Peters, Gilb.*); Porto Escondido (*Nichols coll.*); Chiapam (*Gthr.*); Panama (*Gthr. Gilb.*).

†*Pimelepterus lutescens* Jordan & Gilbert, Proc. U. S. Nat. Mus. iv, 1881, 239. Socorro Island (*Nichols coll.*).

portion very oblique. Caudal deeply forked. Anal low; the second spine a little longer and noticeably stronger than the third, $2\frac{2}{3}$ in head; soft rays posteriorly, not rising above their basal sheath of scales. Ventrals reaching well past vent, their length more than half head. Pectorals long, as long as head, reaching slightly beyond origin of anal.

Head 3 in length; depth $2\frac{1}{4}$. D. IX, 10; A. III, 8; Lat. l. 35.

Color in life: Light olivaceous above, silvery below, sides with distinct tinge of pale yellow. Fins all yellowish; vertical fins margined with black, the spinous dorsal with a jet-black blotch on tip of membrane of anterior spines. Membrane of each spine and ray of the dorsal with a distinct jet-black spot at its base. Ventrals yellow on terminal portion of outer rays only, the very tip of these white. Tip of snout dark. Opercular membrane yellowish above. Lips with some yellow.

A single specimen, $5\frac{1}{4}$ inches in length, was taken in the Bay of Pánama.

The species of *Gerres* found on the Pacific Coast of tropical America may be thus compared:

a. Preopercle entire; anal rays III, 7; body rather elongate; dorsal and anal spines comparatively low.

b. Furrow on top of head for premaxillary processes long and narrow, naked; tip of spinous dorsal more or less abruptly black (this black spot ocellated in the males); teeth not very small.

c. Body elliptical, strongly compressed, the profile not steep; depth little more than one-third of length; cheeks and sides without dark punctulations; lower fins pale; head small, $3\frac{1}{2}$ in length; eye barely one-third length of head ..... GRACILIS.*

cc. Body subelliptical, deeper, and less compressed, the profile rather steep; depth nearly two-fifths of length; cheeks and sides with dark punctulations; head rather large, $3\frac{1}{3}$ in length; eye more than one-third length of head. DOWI.†

bb. Furrow on top of head for premaxillary processes, short and broad, posteriorly semicircular or subtriangular, naked; tip of spinous dorsal becoming gradually dusky; teeth small.

d. Body moderately elevated, the depth barely two-fifths of length; caudal fin moderate, shorter than head; second anal spine not very strong, shorter than third, about one-fourth length of head; ventrals short, little more than half length of head, not reaching vent; sides without dark bars. CALIFORNIENSIS.‡

dd. Body more elevated, the depth about two-fifths the length; caudal fin long, usually longer than head; second anal spine very strong, longer than third, one-third or more length of head; ventrals long, two-thirds head, reaching vent; sides with 8 or 9 dark vertical bars ..... ZEBRA.§

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* *Diapterus gracilis* Gill, Proc. Ac. Nat. Sci. Phila. 1862, 246. Cape San Lucas (*Gill*); Guaymas (*Nichols coll.*); Mazatlan (*Gilb.*); Panama (*Gilb.*).

† *Diapterus dowi* Gill, Proc. Ac. Nat. Sci. Phila. 1863, 162. Panama (*Gill, Steind. Gilb.*); Galapagos Islands (*Steind.*).

‡ *Diapterus californiensis* Gill, Proc. Ac. Nat. Sci. Phila. 1862, 245. Cape San Lucas (*Gill*); Guaymas (*Nichols coll.*); Mazatlan (*Gilb.*).

§ *Gerres zebra* Müller & Troschel, Schomburgk Hist. Barbadoes, 1848, 668: *Gerres squamipinnis* Günther, i, 349, 1849. West Indies; Mazatlan (*Gilb.*): Chiapam (*Gthr.*); Panama (*Gthr.*).

aa. Preopercle serrate; anal rays III, 8; furrow for premaxillary processes naked, broad; teeth very small.

e. Preorbital entire; body without dark lengthwise stripes.

f. Body ovate, the outlines somewhat regularly elliptical, the depth a little less than half length; spines rather slender and short; second dorsal spine half length of head, one-fourth longer than second anal spine, which is less than half length of head ..... AUREOLUS.

ff. Body rhomboid, short and deep, with angular outlines, the depth usually rather more than half length; spines long and strong; second dorsal spine about as long as head, about half longer than the strong second anal spine, which is more than half length of head ..... PERUVIANUS.*

ee. Preorbital serrate; body with distinct dark stripes along the rows of scales; body rhomboidal, with angular outline, the depth a little less than half length; spines very strong, the second dorsal spine two-thirds to three-fourths length of head, about half longer than second anal spine.

f. Pectoral long, reaching about to front of anal; caudal longer than head; lateral stripes numerous ..... LINEATUS.†

ff. Pectoral short, barely reaching vent; caudal shorter than head; lateral stripes few ..... BREVIMANUS.‡

16. **Gobius emblematicus**, sp. nov.

Body rather elongate, compressed, heaviest forwards, tapering regularly from the occiput to the caudal fin. Snout short, rather broad, acute in profile; mouth terminal, very oblique; gape wide, its length nearly half length of head; maxillary reaching to opposite middle of pupil; premaxillaries in front on the level of the pupil. Tip of lower jaw protruding beyond the upper.

Teeth in the upper jaw forming a single row, in the lower jaw partly in two series in front, forming a single row laterally; the anterior teeth in both jaws strong, incurved, and almost canine-like, the lateral teeth smaller and more closely set. Vomer and palatines toothless. Tongue emarginate in front.

Eyes very large, placed high, close together, the interorbital space extremely narrow, scarcely one-fourth the diameter of the orbit, which is greater than the length of the snout and scarcely less than one-third the length of head. Gill-opening moderate, extending from upper angle of opercle to below level of lower edge of pectoral fin.

Scales extremely small, cycloid, scarcely increasing in size toward caudal peduncle; head and anterior part of body to front of dorsal fin naked; a narrow naked strip along base of anterior half of spinous dorsal.

Dorsal spines very slender and weak, some of the middle ones usually prolonged, sometimes reaching nearly to the base of caudal, sometimes

* *Gerres peruvianus* Cuv. & V. vi, 467, 1830: *Gerres rhombeus* Gthr. Fish. Centr. Amer. 1866, 391 (not of C. & V. ?). Mazatlan (*Gilb.*); Chiapam (*Gthr.*); Panama (*Gilb.*); Peru (*C. & V.*).

† *Smaris lineatus* Humboldt, Observ. Zoolog. ii. 185, pl. 46: *Gerres axillaris* Günther, Proc. Zool. Soc. Lond. 1864, 102. Mazatlan (*Gilb.*); San Blas (*Nichols coll.*); Acapulco (*Humboldt*); Chiapam (*Gthr.*).

‡ *Gerres brevimanus* Günther, Proc. Zool. Soc. Lond. 1864, 152. Chiapam (*Gthr.*).

little elevated. Second dorsal and anal similar to each other, their bases elongate, their rays high, the last, when depressed, nearly reaching to the base of the caudal. Caudal fin of moderate length, sharply pointed, the middle rays produced, as long as from snout to base of pectoral. Pectoral fins short and broad, the rays all slender and fine, the upper not silk-like, the fin about three-fifths length of head. Ventrals fully united, the basal membrane very delicate, but well developed, the fin pointed in outline. Insertion of ventrals under axil of pectorals.

Head, 3⅔ in length; depth, 5. D. VII–16; A. 17; Lat. l. about 65.

Coloration in life: Light olivaceous, the belly silvery; above thickly punctate with pale dots; sides very thickly covered with golden-green specks, visible under the lens; back with six pairs of golden-green spots on each side of the dorsal fin, each nearly as large as the pupil; those of the first pair approximate, in front of the spinous dorsal; the second pair is under middle of spinous dorsal; the third pair under end of spinous dorsal; the fourth pair under first third of second dorsal; the fifth pair under the second third; the sixth pair (faint and often wanting) under last rays of soft dorsal. Sides of head and anterior half of body with wide streaks and bars alternately of purplish blue and golden bronze; those on cheeks longitudinal; those on opercle extending obliquely upwards and backwards; those on body vertical. All these markings disappear in spirits, leaving the fish plain light olive, usually with a broad silvery cross-bar behind pectorals. First dorsal transparent dusky, second dorsal with about three series of light blue spots. Anal with a tinge of light pink and a narrow margin of greenish white. Caudal yellowish green below, dusky above; a very conspicuous narrow bright red streak from the lower end of the base to the tip of the 5th or 6th ray from the bottom, thus crossing the rays obliquely. Ventrals glaucous bluish.

This species is very common in the rock-pools in the Bay of Panama, where it hides very closely among the rocks. Numerous specimens were obtained from 2½ to 3½ inches in length.

This species has the dentition of the group called *Euctenogobius*, with the squamation similar to that of the species which have been called *Eucyclogobius*. It may for the present be referred to *Gobius*, although it is not a member of that genus as restricted by Bleeker, Gill, and Günther. In Bleeker's system it would form the type of a new "genus."

17. **Microdesmus retropinnis**, sp. nov. (29665.)

Body very elongate, compressed, tapering somewhat from front of dorsal to caudal peduncle. Head very small, rapidly tapering forward from occiput; upper profile with a noticeable depression behind the orbits, the outline thence to snout strongly convex.

Mouth very small, somewhat oblique, the fleshy tip at symphysis of lower jaw projecting much beyond the premaxillaries; gape scarcely reaching vertical from orbit. Teeth small, apparently in a single series

in each jaw only. Nostrils double, distant, the anterior near the end of snout, the posterior above anterior margin of orbit. Gill-opening a very narrow, somewhat oblique slit, from front of lower third of pectoral fin downward and forward. Branchiostegals evident, 4 or 5 in number. Eye very small, lateral, situated near the upper profile of the head, its diameter nearly half the length of the short snout.

Vertical fins well developed; dorsal and anal connected with the caudal by a very delicate membrane. Distance from origin of dorsal fin to occiput three times the length of the head, its rays distant, connected by thin transparent membrane, as are the rays of the anal; most of the rays simple and undivided (but articulate); a few of the posterior only forked at tip. Origin of anal fin nearly equidistant between gill-opening and tip of caudal, its rays mostly forked at tip. Caudal rays much divided and more closely set than those of dorsal and anal, the fin somewhat pointed in outline, as long as the head. Tail not isocercal, truncate at base of caudal fin. Ventral fins very small, close together, inserted slightly behind base of pectorals; each fin reduced to a single undivided filament. Pectoral fins small, pointed; the middle rays longest, much shorter than the ventrals and half the length of the head.

Vent considerably behind middle of total length of the fish (with caudal).

Head and body covered with scattered rudimentary scales.

Head $14\frac{1}{2}$ in length; greatest depth $15\frac{3}{5}$. D. 48; A. 29; C. 3–17–3; P. 13; V. 1.

Color in life translucent light olive, with a series of irregular quadrate dark blotches along the back and a series along each side, these blotches formed of clusters of dark points.

One specimen, nearly 4 inches in length, was taken in a rock-pool at Panama.

This species differs from the description of the previously known *Microdesmus dipus* Gthr. in the posterior insertion of the dorsal and of the posterior position of the vent, the smaller number of fin rays, the shorter head, longer ventrals, and mottled coloration.

18. **Cerdale ionthas**, gen. et sp. nov. (29664.)

CHAR. GEN.—Allied to *Microdesmus* Günther, from which genus it is distinguished by the presence of two rays in the ventral fin. Its body is much less elongate than in *Microdesmus*. The gill-openings are reduced to small, nearly horizontal slits below and in front of the pectoral fins. The pseudobranchiæ are well developed and the tail is not isocercal.

DESCR. SPEC.—Body considerably elongate, compressed, of nearly equal depth throughout, the head tapering rapidly from occiput to snout; snout short, not obtuse, but the lower jaw heavy and blunt, much projecting beyond the premaxillaries; gape very short and

oblique, the tip of the premaxillary not reaching vertical from orbit. Margin of upper jaw formed entirely by the premaxillaries, which are free laterally, but scarcely movable mesially. Maxillary not distinguishable, probably enveloped in the integument of the snout. Teeth rather strong, short and blunt, in a double series in each jaw, apparently wanting on the vomer or palatines. Lips developed laterally, where they form a fold around the angle of the mouth; lower lip adnate mesially, the upper reduced to an obsolete fold. Length of gape one-fifth length of head. Nostrils two, distant, the anterior at the end of the snout, almost labial, the posterior above front of orbit; both circular. Eye very small, somewhat less than interorbital width or than length of snout. Distance from snout to past margin of orbit contained $2\frac{2}{3}$ times in length of head. Pseudobranchiæ well developed. Gill-opening very narrow, reduced to a short, nearly horizontal slit, extending forward from a point just below the lower base of the pectoral fin. Branchiostegals evident, apparently four in number.

Vertical fins well developed; dorsal and anal both long, the membrane of the last ray of each joining the base of the rudimentary rays of the caudal. Distance from occiput to origin of dorsal fin equal to the length of the head; rays of dorsal fin very slender, distant, the membrane thin and transparent, the rays all articulate, the anterior simple, the posterior bifid at tip. Vent slightly in advance of middle of length of body, the anal fin beginning immediately behind it. Anal rays bifid at tip, excepting the first two, which appear simple. Tail not isocercal, truncate at base of caudal, most of the rays of the caudal springing from the expanded last vertebra. Caudal fin rounded, four-fifths length of head, its rays much branched, more closely set than the rays of the dorsal and anal; rudimentary rays very numerous.

Ventral fins small, close together, inserted slightly in advance of lower end of base of pectoral, each fin composed of two rays, the inner prolonged beyond the outer and bifid at tip, about as long as pectoral fin and three-fifths length of head. Pectorals well developed, broad, the rays branched at tip.

Head and body entirely covered with small scales, which are close-set but hardly imbricate, not arranged in series; mandible, snout, and gill-membrane scaly; scales on belly and breast smaller than the others and more thickly set; bases of caudal and pectoral fins scaled.

Head $7\frac{3}{4}$ in length; depth $10\frac{3}{4}$. D. 41; A. 36 to 38; C. 4–17–4; P. 12; V. 2.

Coloration in life: Body translucent light olive, immaculate below; back and sides very finely marked with clusters of fine dots, the ground color appearing as reticulations between the clusters, which are of irregular size and form; on the sides of the head these dots form bars which radiate from the eye to the snout and lower side of the head.

This species is known from three specimens, from $2\frac{1}{2}$ to 3 inches in length, taken in a rock-pool at Panama.

19. **Citharichthys latifrons**, sp. nov. (29255, 29416, 29425, 29496.)

Subgenus *Hemirhombus* Bleeker.

Body elliptical, the dorsal and ventral outlines equally arched; mouth placed low, below axis of body; snout with an abrupt constriction in front of upper orbit, the outline then again convex; eyes on the left side, distant, the lower in advance of the upper; a vertical line from anterior margin of upper orbit passing through the middle of the lower; distance of upper eye from dorsal outline equaling two-thirds its vertical diameter; interorbital space concave, very wide, its width 1½ times diameter of orbit in a specimen 8 inches long, much narrower in young specimens; a ridge from upper angle of lower eye runs upwards and backwards to join a ridge from upper orbit. Nostrils on a level with upper margin of lower eye, the anterior with a flap, distant from the posterior, which is circular; length of snout to front of lower eye 4⅕ to 5 in head. Mouth very oblique, the gape convex upwards and backwards; maxillary two-fifths length of head, reaching to middle of lower pupil; it is very narrow and covered with small scales. Teeth small; the upper jaw with two series, the front teeth of the outer series somewhat enlarged; lower jaw with a single series; vomer and palatines toothless.

Gill-rakers short and broad, the longest about one-half vertical diameter of pupil; about 7 on anterior limb of arch; pseudobranchiæ present. Preopercle with posterior margin nearly vertical, the lower third only free, the upper two-thirds grown fast to opercle and scaled over; the lower margin running very obliquely downwards and forwards, the angle thus an obtuse one. Dorsal fin commencing on the snout in front of upper eye, the first four or five rays exserted and turned over to the blind side; the highest rays are behind the middle of the fin and are about two-fifths length of head; anal fin similar to dorsal, its origin under base of pectorals. Caudal short, about two-thirds length of head, the middle rays the longest, the outer rays slightly prolonged. Ventrals unsymmetrical, that of colored side on the ridge of the abdomen, the other inserted in front of it. Pectoral of colored side long, the rays very slender, the two upper prolonged and filamentous, the upper (in adults) more than one-third total length; pectoral of blind side more than two-fifths length of head.

Scales ciliated, somewhat irregular, of moderate size, with small scales intermixed; snout naked, head and body otherwise scaly; scales on interorbital region very small; a series of small scales on basal half of each dorsal and anal ray; base of caudal thickly scaled, a series of small scales running nearly to tip of each ray. Lateral line slightly rising anteriorly but without distinct curve.

D. 92; A. 72. Head 4 in length; depth 2⅔; Lat. l. 60.

Head and body light brown, with grayish and light bluish dots, with some darker areas and a few round brown spots ocellated with lighter. Interorbital space with a vertical brown bar bordered by lighter. Fins

similarly marked, the dorsal and anal with a dark blotch on each eighth or tenth ray, the pectoral sometimes with one or more brownish bars.

Not abundant in the Bay of Panama; several specimens were taken, the largest about 10 inches in length.

INDIANA UNIVERSITY, *December* 2, 1881.

ON THE NUCLEAR CLEAVAGE-FIGURES DEVELOPED DURING THE SEGMENTATION OF THE GERMINAL DISK OF THE EGG OF THE SALMON.

By JOHN A. RYDER.

The fact that very complex changes are undergone by nuclei during the segmentation of cells has been known for only a comparatively short time, and, we may add, our knowledge has been greatly increased by the recent advances made in the perfection of histological methods. The titles of the principal memoirs on the subject are given below.*

From the list of papers, it will be gathered that all are German, and by only a few authors. The first of them, Professor Flemming, has described and figured such remarkable cleavage-figures, which he has claimed to have observed in segmenting cells, that it is not to be wondered at that some cotemporaries have been inclined to be incredulous. Since I have been enabled, however, to observe some of these phenomena for myself, I am quite well convinced that he has given us results, the value of which cannot perhaps just yet be properly estimated.

I recently received a series of ova of the common salmon, some of them in the second day of development, from Mr. H. H. Buck, of Orland, Me., in which very complex and interesting nuclear changes were in progress. The germinal disk had not yet begun to spread to form the blastoderm, but the cleavage had advanced so far that it had been segmented into several thousand cells, each measuring about $\frac{1}{300}$th of an inch in diameter. These salmon ova had been preserved in weak alcohol, so that they were not quite as good, perhaps, for our studies as they would have been had they been hardened in very weak chromic acid. The cells were, however, very clear, so that any nuclear figures could be well seen even without other reagents, though upon immers-

* W. Flemming. Beiträge zur Kentniss der Zelle und ihrer Lebenserscheinungen. I Part, Arch. f. mikr. Anatomie, XVI; II Part and supplement, Ibidem, XVIII; III Part, Ibidem, XX.

W. Flemming. Ueber das Verhalten des Kerns bei der Zelltheilung und über die Bedeutung mehrkerniger Zellen. Virchow's Archiv, LXXVII.

Peremeschko. Ueber die Theilung thierischer Zellen. Arch, f. mikr. Anatomie, XVII.

W. Pfitzner. Die Epidermis der Amphibien Morphol. Jahrb., VI.

W. Pfitzner. Ueber den feineren Bau der bei der Zelltheilung auftretenden fadenförmigen Differencirungen des Zellkerns. Morph. Jahrb., VII, Hft. 2.

W. Pfitzner. Beobachtungen über weiteres Vorkommen der Karyokinese. Arch. f. mikr. Anatomie, XX, Hft. 1.

ing the disk for some time in acid carmine, the nuclei were very distinctly brought out, so that all the phases of change which they undergo could be observed in different individual cells composing the disk. In some cells the nuclei were in the resting stage; in fact, such was the case with the majority, and a comparatively small number were observed to be undergoing cleavage with the nuclear matter aggregated at opposite ends of the now elongating nuclear figure. Every phase of nuclear metamorphosis could be studied deliberately after I had made permanent balsam preparations, and from these I have been enabled to make a number of camera sketches, which are almost as complex as any figured by Flemming. These sketches are appended in an accompanying plate.

It is not known in what respect the nucleus differs chemically from the rest of the protoplasm of the cell in which it is embedded, but it is known that it is in some way very intimately concerned in the process of cell-division, a phenomenon which always accompanies growth and development. In the case of almost all, perhaps all organisms, the cells which compose them are constituted of a central more or less refringent body, the nucleus involved in a covering of protoplasm usually more or less different in optical properties from that composing the former. Huxley observes (Anat. Invert. 19), "when nucleated cells divide, the division of the nucleus, as a rule, precedes that of the whole cell." This appears to be the fact in the case of the segmentation of the cells of the germinal disk of the egg of the salmon, but just what share the enveloping protoplasm may take in the process we do not certainly know; doubtless the enveloping protoplasm is just as necessary as an aid or accessory in the process as the nucleus itself; they are probably in some way complementary to each other. To support this view we have the additional fact that we know nothing of absolutely naked nuclei, nor is the evidence in favor of absolutely non-nucleated cells much more than negative. The constancy with which complex cleavage-figures have recently been observed in plants, *Infusoria*, *Protoplasta*, *Mollusca*, *Echinodermata*, *Arthropoda*, and *Vertebrata*, both in the adult and embryo condition, would argue that they invariably accompany and characterize cellular fission or segmentation, and, inasmuch as the reputedly non-nucleated *Monera* propagate by fission, pass through a resting stage just like the cells of other organisms, it would not be surprising to find that they too were provided with nuclei which would develop cleavage-figures in the act of fission. Their complete parity of behavior in all other respects leads us to look for important revelations respecting their complete morphological correspondence with other types of cells as soon as they are studied by the help of improved methods.

Having given the preceding sketch of the function and characteristics of nuclei throughout the animal kingdom, we are prepared to deal somewhat more intelligently with the special case of the cleavage-figures which we have observed in the ova of the salmon. The changes ob-

served in the cells of *Salmo salar* agree in all essential particulars with those seen by Flemming in the cells of the skin and branchiæ of the Salamander of Europe, and are of interest as confirming his observations and also as showing clearly for the first time that similar phenomena occur in the segmenting cells of a species of fish which has been perhaps more thoroughly studied embryologically than any other.

Fig. 1 represents a cell of the germinal disk of *Salmo* with its nucleus in the quiescent or resting stage magnified about 800 times, which is the amplification of most of the figures. In this condition the nucleus is approximately globular and traversed by a very irregular and interrupted network of aggregations, consisting of broken thread-like and rounded granular bodies. This condition is the one which may be supposed to exist during the long intervals of rest between the periods of active segmentation which have been observed by different biologists during the very early stages of development of the ova of various types. This interval of rest may also include a portion of the stages of change undergone by the nucleus preparatory to cleavage, and which will be next described.

Fig. 2 represents the nucleus of a cell from the germ disk of *Salmo* which is elongating and undergoing a rearrangement of its contents preparatory to division. With careful study it was found that nuclei were present in different cells in this stage of metamorphosis. The irregular broken granular threads and granules observed in Fig. 1 were seen, with careful focusing, to have rearranged themselves in the form of an intricate skein-like meshwork of threads, the direction of which was generally more or less in conformity with the long axis of the nucleus. This stage corresponds very closely with similar preparatory stages figured by Flemming and observed by him in *Salamandra*.

Figs. 3, 4, and 7 represent other stages, also preparatory or progressive. In Fig. 4 the nuclear matter exhibits a tendency to aggregate at the opposite poles of the nucleus, while in Fig. 3 aggregations are taking place around the equator of the nucleus as well as at the poles. The equatorial ring of granular aggregations is viewed somewhat obliquely, showing that they occupy a peripheral position against its wall. Fig. 7 represents a nucleus similar to the last, in which we may likewise note the equatorial and polar accumulations of nuclear matter. Cleavage or segmentation of the cell will take place across the plane marked by the equatorial aggregations.

Other phases in this strange cycle of phenomena are represented in Figs. 8, 11, and 12. In Figs. 8 and 12 the nuclear equatorial plate seems to be developed. In Fig. 11 the nucleus has apparently lost its contour, but in all of the last three the nuclear matter has been aggregated into definite stout threads, with enlargements at their ends in two of the cases.

In Figs. 5 and 6 the sharp contour of the nucleus has been finally lost; short, thick, and highly refringent rods have been developed on

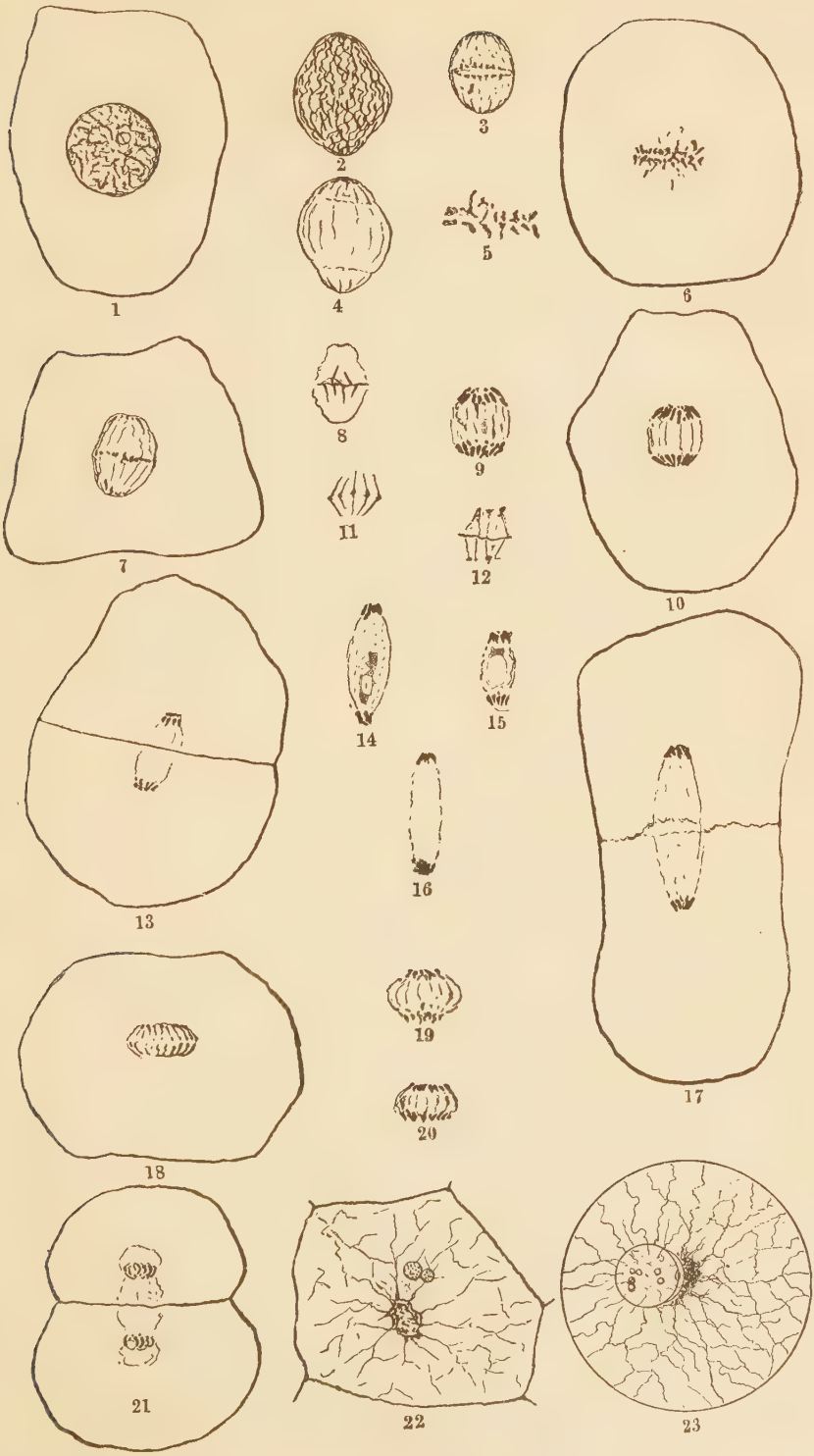
either side of its equator. In Fig. 5 they are very irregular; in Fig. 6 much more regular.

Fig. 18 represents another phase of the progressive stage, in which the refringent nuclear rods at the opposite poles of the nucleus form a loaf-like figure. In this phase the rods seem to be about ready to part at the equator so as to assume the arrangement observed in Figs. 19 and 20. These are also progressive and approximating the conditions shown in Figs. 13 and 15. Figs. 14, 16, and 17 are still further stages in the process and indicate the stage when the cleavage or segmentation may be said to have been completed. In Figs. 9, 10, and 13 to 20, inclusive, it may be observed that the refringent nuclear rods have been aggregated at the poles of the nucleus, where they lie in a bundle somewhat like a bunch of fagots, or in the form of a crown or wreath. As the polar crown-like figures are separated the refringent rods of which they are composed are more and more compacted together into a closer bundle, as indicated in Figs. 14, 16, and 17.

In Fig. 21 the cleavage seems to have been completed, as the two polar nuclear aggregations lie more nearly in the centers of the two new cells. There is still a trace of the rod-like condition of the nuclear matter discernible, but the tendency is retrogressive, that is, to the phase indicated in Fig. 2. This apparently completes the series of rhythmical phenomena which we have observed in the cleavage of the nuclei and cells of the germinal disk of the egg of the common salmon. In Fig. 21 the two new nuclei will undergo a retrogressive metamorphosis until they are like Fig. 1; when this has been done, they will pass into the so-called resting stage, only to repeat the series of changes of form and rearrangement of their substance in subsequent cleavages as described above.

In my paper on the retardation of development of the eggs of the shad I have endeavored to explain why it was that segmentation appeared to go on rhythmically; data similar to these were there laid under contribution to explain away the fact. I had, up to that time, not been able to make any observations of my own on the behavior of the nucleus during the acts of segmentation, and this notice is designed to supplement and reinforce the arguments there put forth. As far as I am aware, the foregoing account is the first which minutely describes the behavior of nuclei in the segmenting germinal disk of any fish, and for that matter, the segmentation of any of the cells of a teleostean.

The stages represented in Figs. 3, 5, 6, 7, 8, 11, 12, and 18 appear to represent, in successive order as named, the *systole* of the nuclear matter towards the equator of the nucleus, while Figs. 18, 20, 19, 10, 9, 13, 15, 14, 16, and 17 similarly and successively represent the *diastole* phases of repulsion from the nuclear plate or equator. The rhythmical nature of the phenomena can, I think, hardly be questioned, nor will any one doubt the propriety of the application of the terms systole and diastole as suggested by Flemming. Lest it be objected that the nuclear figures



NUCLEAR CLEAVAGE FIGURES OF SALMON EGGS.

are the result of the disturbing effects of reagents, let it be remarked here that precisely similar changes have been observed in the living nuclei of both plants and animals.

No connecting granular fibers could, as a rule, be clearly made out between the aggregations at the opposite poles of the nucleus. The connecting lines, when present, appeared to be more or less broken as represented in our sketches, and only a faint outline of the nuclear field between the aggregations could be clearly made out. Neither was it possible to find any granular lines radiating outwards from and beyond the ends of the aggregations into the surrounding protoplasm of the cell in which the nuclei were embedded.

This condition is in very marked contrast with that constantly observed in the connective tissue-cells of the oyster, one of which is represented in Fig. 22 enlarged 800 times. Here a complex network of granular threads passes outwards in all directions from the irregular nucleus through the enveloping protoplasm; besides the threads there are usually one or two globular granular accessory bodies present, as shown in the figure. A still more complex arrangement of granular threads around the nucleus is shown in Fig. 23 of a cell, enlarged 1,000 times, from the reproductive tissues of the smooth limpet, *Crepidula glauca*. This last figure is from a sketch made two years ago from fresh material studied in neutral fluid.

THE DESTRUCTION OF YOUNG FISH BY UNSUITABLE FISHING IMPLEMENTS.

By B. P. CHADWICK.

BRADFORD, MASS., *December* 23, 1881.

Prof. SPENCER F. BAIRD:

DEAR SIR: I take this method of calling your attention to a subject that has occupied my mind for a long time, and that is, the destruction of the young fish along our coast from Cape Henry to Nova Scotia, by the use of ill-constructed nets, pounds, weirs, and traps of every description. For instance, in the seining of mackerel it often happens that 200 barrels are taken at a time; of this amount only 25 barrels are found to be large enough to be of any value in the market, the other 175 barrels are thrown back into the sea, all dead. This is a daily occurrence in a hundred places, and countless millions of young fish are destroyed during the mackerel season annually. The catch of mackerel is of vast importance to this country, and the useless destruction of the young fish is four times the amount of that sold as food. This wanton waste of the young fish can all be avoided by act of Congress, compelling fishermen to use seines, the mesh of which is large enough for the young of a useless size to pass through; thus there would be no fish taken except such as are marketable. This subject is probably nothing new to

you, but upon investigation you will find it of much importance; should you deem it of sufficient importance to bring the subject before Congress, with a view of regulating our fisheries so far as the government has jurisdiction from the shore along our coast, I would be pleased to furnish you with further information and such suggestions as have come to my observation in years past.

Very respectfully,

B. P. CHADWICK,
Deputy Fish Commissioner, Massachusetts.

THE PROPOSED INTRODUTION OF CATFISH INTO GHENT.

By THOMAS WILSON.

UNITED STATES CONSULATE,
Ghent, December 2, 1881.

HON. SPENCER F. BAIRD,
Commissioner, &c.:

MY DEAR SIR: Your letter of the 12th ult. was duly received, together with the pamphlets on carp and salmon, for all of which accept my thanks. My expectation and idea in regard to importation of catfish is as follows: There are many rivers and canals in this city and province which are capable of raising fish in great numbers, but owing to the muddy, sluggish character of the streams, the number of mills of every sort, the locks, &c., &c., together with the increased number of eels, the fish have been driven nearly out; fish like the salmon, pike, &c., &c., will not remain and thrive; therefore, while there are great quantities of water there are few fish. Fish are brought from the sea and are for sale in the markets, but I have thought to utilize these rivers by the importation of fish, such as would live and thrive and would be essentially a poor man's fish, such as could be caught on the banks in the country through which the streams flow. I have talked with the governor of the province and it meets his approbation. He said late laws had been passed for the protection of fish and that this general matter had received the attention of the government. I do not understand that there is any fish society or association in this kingdom, but I think such a step as I propose would excite sufficient attention to result in the formation of one.

Therefore, as a sort of pioneer and *pro bono publico*, I have thought to take this initiatory step solely for the good of the public, and knowing your devotion, &c., &c., to this fish business as one of your specialties, I have thought you and I could make the world a little better from our having lived in it by making the endeavors I have suggested. This is the whole matter. It will be necessary to give me full instructions what to do and how to do it on receipt of the fish. I know virtually

nothing about the manner, &c., of taking care of young fish. Have you no pamphlet giving such directions? I can easily arrange for the freight on the Red Star Line of steamers from New York to Antwerp, and from Antwerp here. I will see that all is paid, and so far as that is concerned you need not delay sending.

There are many canals in this country, very many of which communicate with the rivers direct, and at very short distances, making a network of canal and river extending over large areas of country. These canals have few locks, and are not usually drained or emptied. A look in the encyclopedia at Little Ghent will give you a better idea than I can in any letter. There are 27 canals, long and short, in this city, and 80 bridges.

My query is, Where, in such a system, ought young fish to be emptied? In the canals, or in the river? Ought they to have free access to the sea or lower river, or should it be to the upper river? There is one place which has been lately emptied and cleared of eels and everything, but it is closed at both ends by locks. With all this information, where and how should they be emptied?

A TRANSFER OF LEATHER CARP (CYPRINUS CARPIO) FROM THE GOVERNMENT PONDS AT WASHINGTON, U. S. A., TO SCOTLAND.

By A. WILSON ARMISTEAD.

DOUGLASS HALL, NEAR DALBEATTIE, SCOTLAND,
December 6, 1881.

DEAR PROFESSOR BAIRD: You will be pleased to hear that the 25 leather carp have been safely landed after a very stormy voyage. The gale was a very severe one, and on Wednesday, November 23, the wind blew with hurricane force, and we were obliged to "heave to" for twenty-two hours; the seas were very large indeed. We shipped one during the night which disabled the four seamen on watch; one had two ribs broken and another his head badly cut; the other two were lamed. The wheel-house was "stove in" and the galley bulged in; one boat was carried away on deck, breaking down the chimney-stack of the donkey-engine. Through all this storm the carp did well. The temperature of the water was 50° Fahr. at New York, and during the voyage varied from 54° to 62½°. I also fed them with a little oatmeal and potato four times. The temperature of the water here at this time of year is about 44° to 50°, which, I suppose, will be rather too cold for the carp. I give them a little oatmeal, but think they don't touch it. My brother is much pleased with the carp, and would wish me to thank you for all your kindness. He will value these fish very much, remembering how he came to get them. We have got our fish-hatching house

up now and a few hatching-troughs with *Salmo levenensis* ova in, but the ponds outside will be laborious work. The hatching-house is 80 feet long by 30 feet, and built of granite. The first fry-pond is just finished, and is 60 feet by 4 feet, the bottom made of concrete and the walls built up with granite and Portland cement (three of sand and one part cement). This makes a capital pond. I will try and remember to send you a drawing of the fish-house as it is intended to be when finished. I think my brother has some drawings in hand, but probably it will be some weeks before I can send it.

POLLOCK-FISHING IN BOSTON BAY.

By S. J. MARTIN.

There is something strange about the pollock-fishing.

All through the summer the pollock are caught on the eastern grounds as far east as "Granman" Bank. After the 1st of November you can't find a pollock on the eastern shore. I have talked with four captains of eastern vessels. They tell me they don't come in on the eastern shore to spawn; if they did, there would not be so many eastern vessels fishing in Boston Bay. There is not a rocky spot in Boston Bay that has not plenty of pollock, although there is one particular place where the vessels all anchor. This is called the Old Southeast. It is 7 miles southeast from Half-way Rock. I have seen 75 sail of vessels at anchor in a place half a mile square. They lie so near together that they take the oars to push the vessels apart, and they have seines from one to another; with a sudden change of wind they have to cut cables to get clear. When it is moderate some of the vessels make fast to the vessel at anchor. Most of the vessels carry ten men each. They fish with two lines to a man. Some of the vessels have caught 30,000 pounds in 24 hours. They use some fresh bait, but mostly clams; the older the clams the better. They use clams that have been carried to the Banks. There are 40 sail of eastern vessels up here fishing for pollock. Sometimes on a clear night they catch as many as they do in the day. The pollock this fall have brought a good price, 80 cents per hundred pounds round. Last fall they sold for 60 cents a hundred pounds. The fish are large; the last ones averaged 12 pounds each. There is great excitement in catching them. Where the vessels lie so near, all hands may be heard shouting over the entire fleet.

GLOUCESTER, MASS., *November* 22, 1881.

COD GILL-NETS IN IPSWICH BAY, MASSACHUSETTS.

By S. J. MARTIN.

GLOUCESTER, MASS., *November* 15, 1881.

DEAR PROFESSOR: I thought I would write and let you know how the cod gill-nets are doing. Six vessels have their nets set, and they have done well.

I find that pollock will mesh as well as codfish. The first night the schooner Maud Gertrude set her nets, 12 in number, they got 3,000 pounds pollock, 2,000 pounds cod. The nets were set on Brown's. Their nets were set three nights. They have as many pollock as codfish. The pollock tear the nets badly. The net has too large a mesh for pollock. Captain Gill told me that if the nets had 8-inch meshes they could get them full of pollock. The 10-inch mesh catches large pollock, some of them weighing 20, 21, 21½ pounds. They tore the nets so badly in three nights that they had to put three nets ashore. The pollock are very strong fish. The reason they tear the nets is, that they get half way through the mesh, then they have their head and tail both to work. It takes strong twine to hold them. Two vessels had nets set in Ipswich Bay. They got 12,000 pounds each in two nights with 12 nets each. The Northern Eagle went to Ipswich Bay Monday morning with 24 nets. I think they will do well. There is a good school of fish on the rocks. There are two boats running sperling from Plymouth to Gloucester to sell. There are plenty of pollock. A vessel went out Sunday morning, came in to-day, had 25,000 pounds pollock; 8 men. There are 35 sail fishing after pollock.

I will try and keep you posted on the cod gill-nets.

GLOUCESTER, MASS., *November* 25, 1881.

DEAR PROFESSOR: A few words concerning cod gill-nets. The schooner Northern Eagle arrived from Ipswich Bay Wednesday. Was gone eight days. Landed 33,000 pounds large cod; stocked $800; crew's share, $63 per capita. The fish were all landed in Rockport. They used 28 nets; four 50-fathom nets to a dory. Some of the vessels carry 32 nets. Fish are not plenty. They fetch a big price, averaging three cents a pound. Three years ago one cent a pound was a good price. Last week there were 128 nets set down the bay. Next week there will be 250 nets set in Ipswich Bay. All the vessels that had nets last year can get them cheap. A net 50 fathoms long, 3 fathoms deep, costs $13. Don't have to buy any glass balls, nor head-rope, so the nets come a great deal cheaper. One thing strange, that all the fish are male fish; always before the female fish came first. I was on

board the schooner Northern Eagle Thanksgiving-day. She had 5,000 pounds cod they got the day before. There were but 14 female fish. The male fish are not large, average 15 pounds each; the female fish, 20 pounds each. In two of the female fish the spawn was ripe. A few of the male fish were ripe. One vessel went down to Ipswich Bay with trawls; they did not get enough fish to eat. I will know more about the net-fishing next week, and will try and keep you posted if I can. It is hard to get an account of all the fish that are caught in nets. I will do the best I can.

GLOUCESTER, MASS., *December* 6, 1881.

DEAR PROFESSOR: A few words about the cod gill-nets. When the fish first came on the rocks this fall there was a good school. The hand-liners did well. The netters did well. The fish are scarce now. No fish caught on hand-lines. Some of the boats were out yesterday with frozen herring for bait. Caught no fish. All the fish that are caught are caught in nets. I was down at Rockport last Friday. There were seven boats with codfish. Thursday there were six boats there with codfish. Thirteen boats landed 90,000 pounds of fish last week. All the Portsmouth boats with nets landed their fish in Portsmouth. The Newburyport boats with nets land their fish at Newburyport as near as I can learn. There were 145,000 pounds of fish caught in gill-nets last week. If it were not for the gill-nets we could not get fish enough to eat. There were 26 boats with gill-nets last week. They average 22 nets to a boat. All the vessels that were fishing with trawls are getting nets. There will be 30 vessels with nets. My belief in regard to gill-net fishing is, that if all the boats would take their nets up every morning, and set them at night, it would be better for all concerned. I think the nets scare the fish in the day-time. If the nets were up all day the fish would have a chance to come farther inshore. The nets would last longer. The netters will not do it. If they get their nets on a good spot they want to keep them there. The netters don't sell fish in Gloucester. If I could go to Rockport once a week I could tell very nearly what they get in nets. The fish they got last week sold at two dollars a hundred pounds. The fish I looked at in Rockport were two-thirds male fish.

GLOUCESTER, MASS., *December* 22, 1881.

DEAR SIR: I will send you last week's report of the cod gill-nets. There were 160,000 pounds of codfish caught in cod gill-nets last week. Fish are scarce. Six boats have taken their nets up in Ipswich Bay and set them off here. The fish off here are most all male fish, good size, averaging 19 pounds each. The trawlers and netters don't agree in Ipswich Bay. The trawlers think the nets scare the fish and stop them from coming in. Twenty-nine vessels have nets. Some of the boats have their nets up for repairs. Fish are sold to-day at 1½ cents

per pound; in November they sold for 3¼ cents per pound. The fishermen do not think there will be a large school this winter. I think if all the boats would take their nets up and keep them up a week it would be better for all hands.

I hope next week to give a better report.

Very respectfully,

S. J. MARTIN.

Prof. SPENCER F. BAIRD,
Smithsonian Institution, Washington, D. C.

DRY TRANSMISSION OF FISH-EGGS.

By MAX von dem BORNE.

It is well known that the eggs and milt of fish, when kept separate, die very quickly in water, but that in many cases they will remain alive for several days if kept out of the water. It is to this property that is due the efficiency of the so-called dry method of fertilization. It is also known that it is very difficult to ship recently fertilized eggs of fish in the first stages of their development. Under these circumstances it occurred to me that eggs fertilized entirely dry (if not brought into contact with water at all), and their development thereby delayed, could be more readily transported than if brought in contact with water before the journey, and transported during the first condition of embryonic subdivision.

To test this problem I requested Herr Glase (Basle) to send me some salmon eggs and milt, together, in a hog's bladder, without the addition of any water. This has been done twice, and with them, at the same time, a number of eggs treated and packed in the ordinary manner. The journey lasted three days, and the temperature was high, in spite of which the dry-packed eggs both times arrived in good condition, and were of a beautiful red, while the eggs treated in the ordinary manner were almost all dead and of a very pale color. I propose, hereafter, to investigate whether embryonized eggs may be sent better in the bladders than in the ordinary packing.—*Ö.-U. Fischerei-Zeitung, Vienna, December* 8, 1880.

A DEPOT FOR EMBRYONATED EGGS OF ALL THE VALUABLE KINDS OF FISH.*

By JOSEPH SWETITSCH.

[From Oesterreichisch-Ungarische Fischerei-Zeitung, Vol. IV, No. 4, Vienna, January 23, 1881.]

Mr. Friedrich von Busse, the head of the wholesale fish-house at Geestemünde, and owner of the large piscicultural establishment at

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* "Ein Entrepôt embryonirter Eier aller edlen Fischgattungen."—Translated by HERMAN JACOBSON.

Donnern, is preparing for the next spawning and hatching season in said establishment a permanent depot for embryonated eggs of the most valuable kinds of fish from North America, South America, and from European lakes and rivers, with the view of facilitating the obtaining of embryonated eggs by the piscicultural establishments of all countries, but especially Austria-Hungary, and of thereby giving a general impetus to pisciculture.

There are no difficulties whatever in the way of this undertaking, because Mr. von Busse has 14 vessels of his own continually out at sea, and maintains direct commercial intercourse with America. Mr. von Busse is moreover, during the current year, sending specimens of all the different species of fish found in the North Sea, carefully packed in ice, to Professor Mather in New York, where plaster casts of these fish are taken for the museum of that city. There is, therefore, no doubt that the prominent American pisciculturists, who have so far showed themselves exceedingly generous, will also in the future continue to extend to us their sympathy and generosity.

Austro-Hungarian pisciculturists who should wish to procure some of the above-mentioned embryonated fish-eggs direct from the depot at Donnern are herewith requested to send all orders to the undersigned.

JOSEPH SWETITSCH,

Director of the Piscicultural Establishment at Donnern,
near Bremerhaven, P. O. Loxstedt.

TREATMENT OF FISH EGGS AT SEA.

By von BEHR.

BERLIN, *October* 20, 1879.

The honorable board of directors of the North German Lloyd has for years taken charge of the exchange of fish eggs between American pisciculturists and the German Fishery Association, and has done this with the greatest generosity and entirely gratuitously.

Such small exchanges may possibly also be made during the coming winter without any one accompanying the boxes during the voyage. By the kind co-operation of Captain Neynaber, of the steamer Mosel, we give below all those little hints which should be observed if the precious fish eggs are to reach the other shore of the ocean alive and in good condition.

It is desirable that the honorable board of directors should hand a copy of this circular to every one of their captains, for our American friends sometimes send us a small box with eggs quite unexpectedly, so that we have no time to notify the captain who has charge of them and ask him to take the necessary precautions.

According to Captain Neynaber's opinion, the following are the chief points:

As soon as the boxes have been put on board the steamer they should, without being exposed to the warmth for any length of time, be placed in the *ice-house* on a *layer of matting* so as to avoid *concussions*.

In the ice-house a place should be selected where the thermometer indicates *a few* degrees above zero,* as a lower temperature, if it should enter the boxes, would of course destroy the life of the eggs.

After arriving in port the sailors should be instructed to avoid all *concussions* of the boxes; their stay in a warm atmosphere should be shortened as much as possible; and when the boxes leave the steamer a few pieces of ice should be placed on them.

v. BEHR,
President German Fishery Association.

INTRODUCTION OF CALIFORNIA SALMON INTO ONTARIO, WITH REMARKS ON THE DISAPPEARANCE OF MAINE SALMON FROM THAT PROVINCE.

By SAMUEL WILMOT.

NEWCASTLE, ONTARIO, *November* 10, 1881.

Prof. S. F. BAIRD,
Washington, D. C.:

I have to apologize for the great neglect in not giving you previous notice of the safe arrival of the half million California salmon eggs obtained through your kind instrumentality. They all arrived in the best possible condition and are now hatched, as lively little fish. By far the greater portion of this consignment was sent to the Saint John's River hatchery in New Brunswick. Previous experience having taught me the importance of having a special messenger to look after fish eggs *in transitu*, I sent my son to meet the Californians at Chicago. He dropped off at this station a portion of the eggs for our hatchery here, and proceeded on with the balance (about 350,000) to the Saint John River, meeting with (comparatively speaking) no losses whatever.

This venture will give a very fair trial of what California salmon will actually do in our Atlantic rivers, as I propose turning the whole of the product of this hatchery directly into the Saint John near the hatching-house, which is situated about 200 miles up the Saint John's River from the Bay of Fundy. I trust, for the especial gratification of yourself and myself, these young "Californians" may not turn truants upon us altogether, but that some of them may return to us for further education "in the way in which they should go."

About this time last year I wrote you concerning a strange freak of nature with the salmon in this stream, namely that there were *no males* to be found in the creek to impregnate the eggs of the females with, and that all of the salmon entering it (though much less in numbers than

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*Probably Réaumur.—(Translator's note.)

the previous years) were, with the exception of some three or four, entirely females, and of a very large size. I asked you to explain this peculiarity, or to give me some "scientific theory" for it, if it were possible. You either would not, or could but certainly did not, for I got no communication from you on this phenomenal freak of our salmon. The total absence of "grilse" in the stream last year was also a remarkable fact.

It now appears truly that "wonders will never cease," for I have to tell you of the almost total absence of salmon in this stream. So far this fall only four or five adult fish have yet been seen, although the time is now almost past for their appearance for spawning purposes; only two or three spawning-beds are noticeable in the creek where hundreds were regularly seen in former years. The only show this season is a small lot of grilse, about fifteen or twenty all told, and they look as if they came from some "infernal region," being dirty, black, scabby fellows, lean and lank, as if hybrids between eels and salmon (if such a thing could be).

Facetiously speaking, there is evidently a "missing link" concerning these salmon that were so plentiful in 1878 and for five and six years previously. In 1879 they fell off very largely in numbers, but were all very large fish. In 1880 the reduction was very great, with the strange phenomenon of all being females. In 1881 only half a dozen adult fish and a few dirty discolored grilse have thus far entered the stream.

Whether Professor Hind's theory of the "biennial spawning" of salmon (upheld, I believe, also by my friend Atkins) is being verified here this season I cannot say. [See Mr. Ralson's evidence on page 40 of report of 1879, herewith mailed you.] The evidence is certain, however, that the salmon are not showing themselves in this stream this season, and so far "biennialism" is an accomplished fact; and for consolation for their loss I must only look forward to next year for a regular "Pacific coast" run of salmon, and in such numbers as to crowd themselves upon the banks of the stream. In this idea I confess I have little or no faith, for I fear that the time is now gone by for the production and growth in the frontier streams of Ontario of the salmon and speckled trout. This view has been forced upon me from the many experiments which I have failed to carry out in the trials to restock ponds and streams (with brook trout) within short distances of their entrance into Lake Ontario. This state of things has been brought about by the almost total clearing up of the country, causing many streams to become almost dried up in midsummer, and all others to be greatly reduced in their volume of water. This very much lessened supply becomes overheated from the sun's rays and other atmospheric influences; add to this filth and decomposed matter of all kinds, carried by every rainfall into these streams from barn-yards, plowed fields, turnpike roads, saw-mills, and factories of all kinds; this so pollutes the water that the young of the higher orders of fish, such as salmon and trout, cannot live and thrive in such places.

So marked has this been the case within the past five or six years (and it is constantly increasing) that in small ponds and in the main streams where a few years ago parrs and smolts could be seen in large numbers, it is now quite an exceptional occurrence to see them anywhere. In corroboration of this fact I have only to mention that as a matter of experiment young trout, salmon, and California salmon have frequently been taken from the spring-water tanks and placed in the ponds of creek water, and they invariably die, in the summer months, within a few days, sometimes weeks, after the change is made.

This deplorable and lamentable state of affairs just related brings me to the object I had in view in writing this letter to you; but having digressed so much, I shall now have to be brief on the subject of the carp, which you kindly promised to supply me with this autumn. I got about a dozen (living ones) from New York last winter; they were about 2 and 3 inches long. I put them in one of the smallest of these little creek ponds, and they have done very well. I noticed to-day six of them on the surface of the pond that would measure 10 and 12 inches in length, very fine and plump in appearance. Mr. Armistead, the Eng, lish gentleman who brought out your "soles," called upon me to-day and in going round my ponds, expressed the opinion (from what he saw of yours at Washington) that mine would be very well adapted for the carp. This opinion is also borne out by the growth of the few carp I placed in the smallest and most inferior of these ponds.

May I still look forward to getting from you a number of carp? Our mutual friend, Mr. Whitcher, is most anxious that I should introduce them in our waters.

LIVE PONDS FOR FISH IN NEW JERSEY.

By SMITH E. HUGHES.

CAPE MAY POINT, NEW JERSEY,
November 5, 1880.

Capt. M. P. PEIRCE:

DEAR SIR: Since writing to you, about October 23, there have been new developments with my *weak* or *trout-fish*, and in your letter to me, October 27, you stated you would probably show my letter to Professor Baird, as you thought my enterprise would be of interest to him, and if so, I am sure he would like to know the result of my experiment with these fish.

Professor Baird, I know, wants facts and results, and I will give a full account of my experiment thus far. In June I put about one hundred weak-fish in my pond, which had been prepared for them some time previous to putting them in, and during that time seemingly tens of thousands of pond chubs had gotten in through the one-half inch wire-screen, or else hatched in there, and could not get through the one-half

inch mesh. I looked upon these little fish as excellent food for my weak-fish; but when I introduced the weak-fish (spawning season) most of them died the next day or two after they were put in. I attributed their dying to rough handling and poor facilities for transporting them. The balance, about fifty in number, seemed to be doing well and I was surprised to find that the chubs did not seem to decrease in number, and even more surprised after close examination to find the little chubs swimming all around them without fear of being molested by their larger neighbors.

I think it was in the latter part of July, for an experiment, I also put in fourteen common size sea-bass, and soon discovered the little chubs were in trouble, and in less than three weeks from that time there was not a chub to be seen, and as about one-half the water was drainage from the meadows above, the other half from the bay every tide, concluded to let them all take their chances for food, and did not give them anything. I could never see the bass, but other persons told me they had seen them occasionally. I could see the weak-fish at any time when the pond was nearly emptied and the water running out at the gates; during all July, August, and September, and nearly all of October they seemed to be fat, healthy, and strong. I think it was the 23d of October I wrote to you that they were doing so well; about the 25th or 26th there came a very sudden change in the weather—cold and rain—and the weak fish nearly all died.

Anxious to be certain of the cause of dying, I had my men drag a net all over the pond, and could find but seven or eight still alive; they were fat and strong, but not lively, and I had them placed carefully back in the pond for further developments, and to-day I saw them all still living and apparently in good condition. When dragging the net we could not get one sea-bass. I believe they are living, but the cold weather drove them in the muddy bottom of the pond, and, if so, I fear it would be a difficult matter to get them out; and that is the pond in which I had contemplated putting the carp, should you think it advisable, and appropriate to send some to me for the experiment.

Would not even one of these greedy fish, if left in the pond, destroy or eat up the carp, and, if so, would you think it advisable to try them?

Should you decide for me to try them, I will drag a net over the pond again to see if I can capture them. With the experience I have so far, I contemplate stocking my ponds in May and June with weak-fish from the bay, from thirty to fifty thousand pounds; keep them during spawning season, and take them out for market in August, September, and the fore part of October.

In November and December I contemplate stocking the ponds with all the rock-fish I can capture from the bay, and perhaps take them out in February and March for market, reserving the largest spawning fish if they can be kept during the summer. I also think I shall have an

excellent place for growing and fattening oysters, which I have been told would produce ample food for the fish the year round. I have but little experience in this new business to me, and would be thankful for any suggestions that you or Professor Baird may give me in the enterprise, and, if I can communicate anything new and of interest to you, will gladly do so.

NOTES AND SUGGESTIONS CONCERNING THE FLORIDA SHAD FISHERY.

By J. H. OSBORN.

SORRENTO, ORANGE COUNTY, FLORIDA,
December 18, 1881.

Hon. SPENCER F. BAIRD,
Commissioner of Fisheries:

SIR: At your request I will give you such information as I can in relation to shad. I fished for six years on the Hudson at Hyde Park; have fished on the Upper Saint John's, at the mouth of Lake Munroe, for the past five winters. In the winter of 1876 and 1877 shad were very plentiful; I could catch as high as 200 in one day.

I use a drift-net, 5-inch mesh (string measure), 25 meshes deep. The average depth of the river is 15 feet. Shad have been dropping off for the past two winters, until now I have to fish nights to catch fifty shad with a net 300 feet long. (The river is about 150 yards wide.) With two other drift-nets beside my own (which would cost about $20 apiece) during the month of March I could catch about 300 a day. Shad run here from January 10 up to about the 25th of March. We do not fish after March 1, because they get very soft after that time. They are ripe about March 5, and are running the best then. I think the river ought to be stocked as high up as possible, say at the head of Lake Harney or Lake Jessup. The lakes are dead water, or, in the North River parlance, slackwater. They are very shallow, only about 7 feet in the channel, with a very gradual bottom, and good sandy beach. In March the water gets very warm on the shores of the lakes. The river proper has no beach; 10 feet of water 3 feet from shore. Would have to catch the shad at the mouth of the lakes in the narrow river. If I can be of any service to you, will be only too happy to help to get the river stocked. I think we ought to have some laws to prevent setting gill-nets at Palatka and Melaka. They completely block the river, and prevent any shad from coming up.

Hoping we may get our rivers stocked in the near future,

I am, respectfully, yours,

J. H. OSBORN.

REPORT OF A COMMITTEE OF THE WYOMING HISTORICAL AND GEOLOGICAL SOCIETY ON THE EARLY SHAD FISHERIES OF THE NORTH BRANCH OF THE SUSQUEHANNA RIVER.

By HARRISON WRIGHT, CHAIRMAN OF THE COMMITTEE.

Prof. SPENCER F. BAIRD,

United States Commissioner of Fisheries,

SIR: The committee of the Wyoming Historical and Geological Society, to whom your inquiries touching the old shad fisheries on the North Branch of the Susquehanna were referred for investigation, would respectfully report that they have interviewed, by letter or in person, a large number of the old settlers, who either now live or formerly did live near the banks of the river, and were calculated to be able to give the requisite information, and who were pleased to report. These persons have, in nearly every instance, most cheerfully and at no little trouble furnished us with the information asked. We make this acknowledgment for the reason that the parties to whom application was made are necessarily far advanced in age, all with but one or two exceptions having seen their "three score years and ten," and to them it was no little labor to write out their reminiscences of the early shad fisheries.

Besides these interviews, the records of the county, files of old newspapers, the numerous printed histories of this section of country, have been consulted, and from these various sources the data upon which this report is based have been gleaned. With these preliminary remarks let us proceed to our report.

HISTORY.

There can be no doubt but that the Indians, for years before the white people thought of settling at Wyoming, caught their shad there in large quantities; their net-sinkers, though they have for years been collected by archæologists, are still very plenty, and can be found anywhere on the flats along the river in quantities, and the fragments of pottery show unmistakable markings with the vertebræ of the shad; these, together with the fact that the early settlers saw the Indians catching shad in a seine made of bushes (called a bush-net), point to the fact that shad on the North Branch were taken in quantities by the Indians.

The Connecticut people who settled here over a hundred years ago had, in the very start, their seines, and took the shad in numbers; as near as we can learn they were the first white people who seined the shad in the North Branch.

During the thirty years' war which the Connecticut settlers had with the Pennsylvania government for the possession of this valley of Wyoming, the shad supply was a great element of subsistence; for this,

unlike the fields, barns, and grainaries, could not be burned by the Pennamites. An old settler says: "When we came back to the valley we found every thing destroyed, and the only thing we could find to eat were two dead shad picked up on the river shore; these we cooked, and a more delicious meal was never partaken of by either of us." One of the most bitter complaints made against the Pennamites, in 1784, was that they had *destroyed the seines.*

After the Revolutionary war had ended, and the troubles between the Pennsylvania claimants and the Connecticut settlers had been quieted, the shad fisheries increased in numbers and value yearly, until about the year 1830, when the dams and canal were finished and an end put to the shad fisheries.

RUN.

It would appear, from the papers hereto attached, that the male fish preceded the female fish by some eight to ten days in their ascent of the river, and between the ascent of the former and that of the latter there was generally a preceptible rise in the river, and immediately following it came the large roe-weighted females in great schools.

FISHERIES.

Accompanying this report is a map of the Susquehanna River from the junction of the West Branch at Northumberland to Towanda near the New York State line; upon this is noted the localities of the fisheries with as much accuracy as was attainable from the accounts received by us. Some have probably been omitted, especially in the stretch of river from Danville to a point four miles above Bloomsburg, where we were unsuccessful in our inquiries, but without doubt the most important on the river have been recorded by us.

At Northumberland, or just below, was Hummel's fishery; between Northumberland and Danville there were eight fisheries in order from Northumberland up, as follows: 1. Line's Island lower fishery; 2. Line's Island middle fishery; 3. Smith's fishery; 4. Line's Island upper fishery; 5. Scott's fishery; 6. Grant's fishery; 7. Carr's Island fishery; 8. Rockafeller's. The next fishery of which we have a record was the fishery of Samuel Webb, located about four miles above Bloomsburg. Above this point about four miles, and six miles below Berwick, was the fishery of Benjamin Boon; the next was located just above the town of Berwick, and about a mile and a half above Berwick was the Tuckahoe fishery (this last is the same as the Nescopeck fishery mentioned in Pearce's history); the next was at Beach Haven. Between this latter place and Nanticoke Dam there were three, viz, one at Shickshinny; one just below the mouth of Hunlock's Creek, and one called the "Dutch" fishery on Croup's farm. Above Nanticoke there was one belonging to James Stewart, about opposite Jameson Harvey's place; one at Fish Island; and one at Steele's Ferry, called the Mud

fishery. The next was on Fish's Island, three-quarters of a mile below the Wilkes-Barre bridge; the next was Bowman's fishery, immediately below the Wilkes-Barre bridge; the next was the Butler fishery, a little above the bridge; the next was at Mill Creek, a mile above the bridge; the next was the Monacacy Island fishery; the next Carey's; the next was on Wintermoot Island, this last landing on the left bank above the ferry at Beauchard's; the next was at Scovel's Island, opposite Lackawanna Creek; this and the Falling Spring fishery next above belonged to parties living in Providence, away up the Lackawanna. The next above was at Harding's, in Exeter township; the next above was at Keeler's in Wyoming County; the next was at Taylor's (or Three Brothers) Island, this latter fishery was no doubt the one referred to by P. M. Osterhout as being opposite McKune's station on the Lehigh Valley Railroad; the next was at Hunt's ferry *circa*, five miles above Tunkhannock; the next was Grist's Bar, about a mile above Meshoppen; the next was at Whitcomb's Island, a mile below Black Walnut bottom; a half a mile above this fishery was the Sterling Island fishery; and the next above was Black Walnut, and half a mile further up was the Chapin Island fishery; the next was at the bend at Skinner's Eddy; the next was at Browntown, in Bradford County; the next was at Ingham's Island; the next was at the mouth of Wyalusing Creek; two miles further up was one at Terrytown; the next and last that we have any record of was at Standing Stone, about six miles below Towanda.

Thus it will be seen that between Northumberland and Towanda there were about forty permanent fisheries.

MONEY VALUE.

Our country records only go back to 1787. We spent a whole day in searching the first volumes, in hopes that we might find some entries of transfers of fishing rights, but our search was fruitless; we have, however, found among the papers of Caleb Wright a bill of sale of a half interest in a fishery between Shickshinny and Nanticoke, called the "Dutch fishery"; the price paid was £20 "lawful money of Pennsylvania," equivalent to $53.33.*

Jameson Harvey says that Jonathan Hunlock's interest in the Hunlock fishery was worth from five to six hundred dollars per annum; it was a half interest. Henry Roberts says a right in a fishery was worth from ten to twenty-five dollars.

Major Fassett's father was one of eleven owners in the Sterling Island fishery, and his interest was valued at $100.

Mr. Hollenback's information on the money value of the different fisheries is by far the most valuable; he says the Standing Stone fishery was worth from $300 to $400 per annum; the Terrytown fishery was worth about the same; the Wyalusing Creek fishery was worth about

*Caleb Wright's son received as his share of one night's fishing at this fishery 1,900 shad.

$250 per annum; the Ingham Island fishery $50 less; the Browntown and Skinner's Eddy fisheries about $150 per annum each.

Jameson Harvey says: "The widow Stewart, at the Stewart fishery, used often to take from $30 to $40 of a night for her share of the haul."

The data bearing upon this point are decidedly unsatisfactory, as they would only give to the forty fisheries an annual value of about $12,000, a large amount for those days, yet one we believe to be too small; the next item, the "catch," should be taken with this one to form a basis for calculation.

CATCH.

At the eight fisheries near Northumberland large numbers of shad were taken; three hundred was a common haul; some hauls ran from three to five thousand. The Rockafeller fishery just below Danville (about the year 1820), gave an annual yield of from three to four thousand, worth from 12½ cents to 25 cents apiece.

Mr. Fowler says that the fishery just above Berwick was one of the most productive; and that he has assisted there in catching "thousands upon thousands," but does not give the average annual yield; he also says, that at the Tuckahoe fishery "many thousands were caught night and day in early spring"; and at the Webb and Boon fisheries the hauls were immense; at the latter they got so many at a haul that they couldn't dispose of them, and they were actually hauled on Boon's farm for manure.

At Hunlock's fishery the annual catch must have been above ten thousand.

At the Dutch fishery in one night thirty-eight hundred were taken.

At the Fish Island fishery, at a single haul, nearly ten thousand shad were taken.

Mr. Jenkins recollects of seeing a haul at Monocacy Island—just before the dam was put in—of twenty-eight hundred.

At Scovel's Island the catch was from twenty to sixty per night; at Falling Spring fifty to three hundred per night; at Taylor's Island from two hundred to four hundred per night.

At Wyalusing the annual catch was between two and three thousand; and at Standing Stone between three and four thousand.

The daily catch at the Terrytown fishery was about one hundred and fifty.

Major Fassett says that at the Sterling Island fishery "over two thousand were caught in one day in five hauls."

It is a plain deduction from the above facts that the fisheries down the river were much more valuable than those above. Above Monocacy we hear of no catch over two thousand, while below that point they were much larger, and while from three to four hundred dollars seems to be the general annual value above, we find the fishery at Hunlock's, 12 miles below, was worth from a thousand to twelve hundred per annum.

The shad further up the river appear to have decreased in numbers yet to have increased in size, and that brings us to the next head.

SIZE.

The opinion seems to be general that the great size attained by the Susquehanna shad was attributed to the long run up the fresh-water stream (carrying the idea of the survival of the fittest); that they were of great size is beyond doubt, nearly every one who recollects them insists on putting their weight at almost double that of the average Delaware shad of to-day.

Mr. Van Kirk gives as the weight of the shad caught at the fisheries in Northumberland and Montour Counties as from three to nine pounds.

Mr. Fowler says he has assisted in catching thousands weighing eight and nine pounds at the fisheries in Columbia County.

Mr. Harvey, speaking of the Luzerne County shad, says: "Some used to weigh eight or nine pounds, and I saw one weighed on a wager which turned the scales at thirteen pounds!"

Major Fassett, speaking of those caught in Wyoming County, says: "The average weight was eight pounds, the largest twelve pounds."

Dr. Horton says of the shad caught in Bradford County, that he has seen them weighing nine pounds; ordinarily the weight was from four to seven pounds.

PRICE.

The price of the shad varied, according to their size, from 4*d.* to 25 cents, depending of course upon their scarcity or abundance, and as some of our correspondents remember the price in years when it was high, and others in those when there was a great plenty of fish, there arise what appear to be conflicting statements in their letters.

At the town meeting held at Wilkes Barre, April 21, 1778, prices were set on articles of sale, *inter alia*, as follows: Winter-fed beef, per pound, 7*d.*; tobacco, per pound, 9*d.*; eggs, per dozen, 8*d.*; shad apiece, 6*d.* At one time they brought but 4*d.* apiece. A bushel of salt would at any time bring a hundred shad.

At the time the dam was built they brought from 10 to 12 cents. On the day of the big haul Mr. Harvey says they sold for a cent apiece (Mr. Dana says 3 coppers).

Mr. Isaac S. Osterhout remembers a Mr. Walter Green who gave twenty barrels of shad for a good Durham cow.

Mr. Roberts says that in exchanging for maple sugar one good shad was worth a pound of sugar; when sold for cash shad were worth 12½ cents apiece.

Major Fassett says the market price of the shad was $6 per hundred.

Dr. Horton says the shad, *according to size*, were worth from 10 to 25 cents.

Mr. Hollenback, in calculating the value of the fisheries near Wya-

lusing, has put the value of the shad at 10 cents apiece. In 1820 they were held in Wilkes Barre at $18.75 per hundred. Mr. Fowler says they were worth 3 cents or 4 cents apiece.

COUNTRY SUPPLY AND TRADE.

Every family along the river having some means, had its half barrel, barrel, or more of shad salted away each season; and some smoked shad hanging in their kitchen chimneys; but not only those living immediately along the river were the beneficiaries, but the testimony shows that the country folk came from fifty miles away to get their winter supply, camping along the river's bank, and bringing, in payment, whatever they had of a marketable nature. They came from the New York State line, and from as far east as Easton, bringing maple sugar and salt, and from as far west as Milton, bringing cider, whisky, and the two mixed together as cider royal, and from down the river, and away to the south towards Philadelphia, bringing leather, iron, &c.

Mr. Isaac S. Osterhout says when quite a boy (1822–'23) he went with a neighbor to Salina, N. Y., after salt, he taking shad and his neighbor whetstones, which they traded for salt. The teams hauling grain to Easton brought back salt; in good seasons the supply of this latter important item always seems to have been short of the demand.

The shad, as far as we can learn, appear never to have gone up the West Branch in such quantities as they did up the North Branch, and the same may be said of the Delaware, or else the fish were of inferior quality, for the dwellers from the banks of both of these streams came to Wyoming for their supply of shad.

Mr. P. M. Osterhout tells of a firm (Miller & McCord) living at Tunkhannock, which did quite an extensive business in shad, sending the cured ones up the river into New York State, and far down the river.

Mr. Fowler says, "No farmer, or man with a family, was without his barrel, or barrels, of shad the whole year round. Besides furnishing food for the immediate inhabitants, people from Mahantango, Blue Mountains, and, in fact, for fifty miles around, would bring salt in tight barrels, and trade it for shad."

Mr. Harvey says: "Boats coming up the river used to bring leather, cider, whisky, cider royal, salt, iron, &c., and would take back shad."

OTHER FISH.

We do not find that any other deep-sea fish (with the exception of eels) ever came up the river above Northumberland. The "Oswego Bass," "Susquehanna Salmon," "Yellow Bass," "Striped Bass," Susquehanna Bass" spoken of by the different correspondents appear to be the same fish, which is also sometimes called the wall-eyed pike; an excellent fish introduced into the river many years ago from Oswego Lake; they are not now as plenty as formerly, though within the past few years

they have been increasing perceptibly. The other fish mentioned are nothing but the common river fish.

EFFECT OF DAMS.

There is no question that the building of the dams necessary to feed the canals put a stop at once to shad fishing; all our correspondents agree that after the Nanticoke dam was finished, in 1830, no shad were ever caught above it. As to the effect of the dams on the shad fishing, the following extracts from Hazard's Register are of interest:

1829. May 9, page 304. "Lewistown, Pa., May 2. It is stated that shad are caught in much greater abundance below the dam at North Island, in the Juniata, than has ever been known at any previous time. It is supposed that the dam in the Susquehanna, immediately above the mouth of the Juniata, has the effect of directing their course up the Juniata. The dam at North Island retards their further passage, and the consequence is that the people further up the Juniata are deprived of the luxury of fresh shad which so abundantly falls to the lot of their neighbors a few miles lower down. But we must be content with these little deprivations by the promise of the immense advantages which are to accrue to the country from the canal."

1830. May 8, page 304. The Sunbury Beacon of Monday the 26th of April, says: "Not less than from four to five thousand shad were caught on Saturday last within a quarter of a mile *below the dam*. Upwards of five hundred were taken by one dip-net, and several others averaged two and three hundred each. We understand that several hundred were caught with dip-nets yesterday."

1831. May 14, page 318. From the Wyoming Herald: "Wilkes Barre, May 6, 1831. While the raftsmen complain of the Nanticoke dam, the boys find in it a source of amusement. The bass which ascend at this season in great numbers, stopped by the dam, offered fine sport. Indeed, hooks. half a dozen at a time without bait, are let down and suddenly drawn up often with two or three bass hooked by the side."

And on the same page, from the Susquehanna Democrat: "A short time since great quantities of bass were caught in a small eddy formed in the river directly below the abutment of the Nanticoke dam. The fish apparently lay there in schools, and by drawing hooks through the eddy numbers were caught. On Thursday and Friday last a number of fine shad were caught in the same way. One man drew out nine in one day, and sold them for 50 cents each. This is the first instance within our knowledge of shad being caught with a hook. We mention the fact as one altogether new, as well as to say to the down-river folks, our market has not been altogether destitute of shad, though many a gentleman's table has."

We are informed that to-day the shad manage to get over the Columbia dam, only to be received in nets spread for them at the head of the sluice-way by a pack of scoundrels, among whom, if we hear cor-

rectly, are parties connected with our State fish commission; if it were not for this we would have shad in small quantities as far up as the next dam at all events. The cutting off of this staple of food from tens of thousands of people in this section of country could not but be a great loss, and it has been questioned if it was not greater than the benefits derived from the great internal improvements. Some slight improvements in the sluice-way of the lower dams and a regular ladder-way in that of the Nanticoke dam; good protective laws, well enforced (with a double-barreled shot gun for Columbia dam); certain days set for fishing along the river, and one good stocking with young shad would, we believe, give us shad in fair quantities all the way up the river.

We do not believe the expense would be very great, whereas the benefits would be incalculable. There is no doubt that the experiment is well worth trying.

Luzerne County will contribute her share towards the necessary improvements.

All of which is respectfully submitted.

HARRISON WRIGHT,
Chairman of Committee.

WILKES BARRE, *May* 27, 1881.

LETTERS.

NORTHUMBERLAND, PA., *May* 25, 1881.

DEAR SIR: Your communication of 24th instant, touching fisheries in the North Branch of the Susquehanna, at hand and contents noted. In reply, I take pleasure in saying that my recollection of the shad fisheries dates back to the year 1820; in that year, and the succeeding two or three seasons, I fished at Rockafeller's fishery near Danville; in our party there were six of us; we fished with a seine 150 yards long, and caught somewhere from 3,000 to 4,000 marketable shad, weighing from 3 to 9 pounds. At that time there were eight fisheries between Danville and Line's Island, located as follows: Rockafeller's, just below Danville; next Carr's Island; next Grant's fishery; next Scott's, near where my residence was; next Line's Island upper fishery; next Smith's fishery; next Line's Island middle and lower fisheries. At all these points large quantities of shad were caught, and they were sold from 12½ cents to 25 cents apiece. I have heard of hauls containing from 3,000 to 5,000, and 300 was a very common haul. People came from 12 to 15 miles for shad, and paid cash exclusively for them.

Salmon, rockfish, pike, eels, suckers, and a general variety of fish were caught in addition to shad, and we always had a ready market for them for cash. No shad have been taken since the canal was built, and all other fish have sensibly decreased since that time.

The cutting off of the shad supply was a great and serious loss to this community, from both a monetary and economic view, since this fish in its season was a staple article of food, and employed in the taking and handling quite a large proportion of the inhabitants. This industry was wholly abolished by the erection of these dams, and thousands of dollars of capital invested in the business were instantly swept out of existence. The first fishery below this place was known as Hummel's fishery, and its reputation was good. I never fished there myself, but was well acquainted with it by the speech of my neighbors. In fact all of these fisheries were profitable investments, and the loss of them to this section of the country was incalculable. All of the fisheries mentioned above, except Hummel's, were between Northumberland and Danville. I am sorry that you did not give me more time to prepare this matter for you, since any mention of those good old times brings up a flood of recollections, and the difficulty is, not to remember what occurred in those days, but to sift out what would be useful in this connection, and omit all useless lumber; more time would have brought out a fuller and more detailed statement, but this perhaps is all that is essential, and trusting you will find it of use,

I have the honor to be, very respectfully, yours, &c.,

JOSEPH VAN KIRK.

FALLS, PA., *March* 24, 1881.

In response to your inquiries regarding shad fisheries in the Susquehanna, between Tunkhannock and Lackawanna Creeks, are, according to my recollections: The first at the head of Scovel's Island, opposite Lackawanna Creek; not many shad were caught here, say from twenty to sixty per night; the next was at Falling Spring, same seine as that used at Scovel's Island; the number of shad caught here ran from fifty to three hundred per night; the next above Falling Spring was at Keeler's Ferry (now Smith's); this was a small fishery and only used when the water was too high to fish at other points; the seine was hauled around a deep hole to bring in the shad; the next and only fishery between this and Tunkhannock Creek was at the head of Taylor's Island or the "Three Brothers." This was an important fishery; more shad were caught here than could be taken care of, on account of the scarcity of salt. I can speak of this fishery from experience since 1812. The catch per night ran from two to four hundred; the shareholders attended to it as closely as to their farming or other business, as it was our dependence in part for food. Shad were oftener exchanged for maple sugar than sold for cash—one good shad for a pound of sugar; large shad were worth 12½ cents apiece. A right in a fishery was worth from ten to twenty-five dollars. Shareholders made a practice of salting down more or less shad during the season. An incident in connection with shad-fishing presents itself to my mind, related often by my grandmother. A party

of Indians returning from a treaty at Philadelphia landed their canoes, came to her house to borrow her big kettle to cook their dinner in; after building the fire and hanging over the kettle they put in the shad, just as they were taken from the river, with beans, cabbage, potatoes, and onions. My grandfather, David Morehouse, one of the early Connecticut settlers, then owned the same farm I now own and occupy. I am now in my eighty-seventh year.

Yours, very respectfully,

HENRY ROBERTS.

MOUNT VERNON, OHIO, *March* 19, 1881.

DEAR SIR: I noticed in the Union-Leader an article in reference to the old shad fisheries of the Susquehanna River, and it brought back to my memory many things that happened in my boyhood days, among which were the old fishermen and the knitting of the shad seines. The seines were knit in sections by the shareholders, each one owning so many yards of the net, and each one receiving his share of fish according to the number of yards owned. I lived one year with Mr. Pierce Butler, where I learned to knit seines, and have never forgotten it. We used to knit on rainy and cold days and evenings, and when the sections were all done, Dick Covert, with the help of John Scott, would knit them together and hang the same, put on the corks and leads; this was considered quite a trick, and but few would undertake the job.

I remember I used to go over on the beach on the line of the Butler and Dorrance farms and help the fishermen pick up the shad, and when the luck was good always given one to take home. I remember seeing the shad put in piles on the beach, and after they were all equally divided some one would turn his back and the brailman would say, "Who shall have this?" until they all received their share, one pile left out for the poor women. The boats with the seine shipped would row up to the falls, and then hauled out down by the riffles opposite where Dick Covert used to live. I think it was a bad day for the people along the Susquehanna when the shad were prevented from coming up the river; the fish would be worth more to the people than the old canal. You had better buy the canal, put a railroad on the towing-path, burst up the dams, and increase the value of all the flats above the dams, and you would not have as high water at Wilkes Barre, and there would be less damage done to property; then you would have plenty of shad and all other kinds of fish, and then I think you could afford to send some to your friends out West. I got an old fish-dealer here to send to Baltimore for some shad last week, but they had been too long out of water and too far from home to be good. It used always to be said that there were no shad like the old Susquehanna shad. * * *

Truly your friend,

H. C. WILSON.

KANSAS CITY, *March* 22, 1881.

DEAR SIR: Your letter of the 15th was duly received, inquiring as to my knowledge of shad fishing in the North Branch of the Susquehanna River. I have no remembrance of any being taken at or near Sheshequin, but at Wilkes Barre I have seen them caught in seines before any bridge was built there. The nets were drawn out on the north side of the river. I don't remember to what extent was the catch, but I have often heard my mother say that immense quantities were taken in the vicinity of her father's, who lived about a mile below the old "Red Tavern," in Hanover; that at one haul 9,999 were caught; that when they had got all they could procure salt to cure, or sell for three coppers, they gave to the widows and the poor and hung up their nets, though the shad were as plenty as ever. In 1816 I went to Owego to live, and there became acquainted with a Mr. Duane, who was one of the men who drew the net. He said the actual number was 9,997, but two more were added to make the figures all nines.

When the Nanticoke dam was built the shad could not come above it, and men were in the habit of fishing there with a three-pronged hook, sinker, and stout line and pole. This was sunk, and after a few minutes quickly jerked up. I caught two in that way; others had better luck, and it was reported that one man caught seventy in one day; but I think a large reduction would come nearer the truth.

Probably E. Blackman, of Pittston, could give some information regarding shad fishing at Towanda and Sheshequin. Jesse Brown, long a resident of Sheshequin, and in his youth a resident of Wyalusing, I think; also Chester Park, of Athens, I presume, could give information upon the subject. The Park family kept the ferry at Athens at an early day. Both of the above-named, I think, are over eighty years of age.

I have been examining some old Gleaners of 1811 and 1812, but don't find any of the spring numbers. Some years ago I gave to my son-in-law, L. B. Wyant, of Harvard, McHenry County, Illinois, a roll of Gleaners of 1811 for his museum, which he opens at "Kay's Park," on Geneva Lake, Wisconsin, in summer. As it is getting to be a great watering-place, I expect to spend the summer there, and will examine the papers and may find some item in relation to shad fishing. If so, will write you.

Yours respectfully,

ALVAN DANA.

SCOTTSVILLE, *March* 10, 1881.

DEAR SIR: Yours in regard to shad fishing, I referred to father, and I received the following answers: 1st. There were two permanent fisheries, one at Sterling's Island and one below Wyalusing Falls, besides other places where they sometimes fished, viz., Grist's Bar, Chapin's Island; Whitcomb Island was also fishing ground, but not permanent-

2d. Sterling's Island was the best ground. 3d. Over 2,000 were caught in one day at five hauls. 4th. The market price was $6 per hundred. 5th. The average weight was 8 pounds, the largest 12 pounds. 6th. They also caught suckers, yellow bass, and sunsbitches (what we call carp). 7th. None were caught after the canal and bridges were constructed to my knowledge. 8th. The first fishing was done by the Connecticut people. Father says that in 1806 his father had a share in the Sterling fishery; there were eleven shares, valued at $100 each. Says his father was not much of a fisherman. Hoping these answers may be of some benefit.

I remain, very truly yours,

ALVAH FASSETT.

HOT SPRINGS, ARK., *March* 24, 1881.

MY DEAR SIR: Have not been well since the receipt of your letter, which must be my apology for not answering sooner.

In attempting to answer the questions propounded by the United States Commissioner of Fisheries, I must from necessity confine myself to the shad fisheries within Wyoming Valley.

1st. "Fix the number of fisheries and their location as far as is now practicable."

My memory carries me back to the fishery at Monocacy Island, the one below the falls, near the mouth of Mill Creek. One at Plymouth (in part a night fishery) one at or immediately below Nanticoke Falls. No dam obstructed the shad at that point then.

The fishery near Mill Creek was regarded as the main or most reliable fishery, as it could be fished at stages of water when some of the others could not, and much the largest number of shad were taken there, sweeping as did from the foot of the falls, nearly the entire river to the bar—drawing out upon the lands of late father, where it was my busines as a lad every evening after school, to be with horse and wagon to receive our share of shad. No unpleasant duty, for well do I remember as they came sweeping in to the beak, the net in rainbow form. The corks indicating the position where "Captain" Bennett (father of the late John Bennett, esq., whom you will remember) would discharge his men from the sea or large boat with the outer brail, and passing out and along the net, on the discovery would shout, "Here's shad, boys; hold down the lead line; here's shad." True to the word, long before the main body of the net was drawn up to the shore we youngsters would take up the "Captain's" cry, as the large shad darted back and forth between the incoming net and the shore. What think you, my dear Sec., would not a return of such scenes start a shout from older heads?

2d. "As to the money values or rental of the fisheries."

Of this I have no data from which to form an opinion. As the fisheries were established by the first settlers, joining their limited means with the land owners, forming a company there by common consent to

their children, none were rented as far as my knowledge extends. Owners of rights would allow men who had none to fish for them on shares, thus extending the benefits as far as possible. Good feeling pervaded the community in those days.

3d. "Were other fish taken in any considerable quantity; if so, what kinds?"

With the exception of an occasional striped bass, or, as they were then called, "Oswego bass," of large size (supposed to have been introduced to the headwaters of the Susquehanna from that lake), none of value were taken, as the nets were woven for large shad only.

I cannot better illustrate the value and importance of the shad fisheries at that early day to the people on the Susquehanna River than to repeat an anecdote told me long years after by a genial gentleman of New England, who in youth visited my father at his home in Wyoming.

Leaning on the front gate, after breakfast, as the little children were passing to school, each with a little basket, the universal answer from their cheery, upturned little faces was, "Bread and shad," "Bread and shad" (corn bread, at that).

What think you, my dear sir? Had that fish diet anything to do with the known enterprise of that generation? If so, would it not be well to make a strong and united effort to again introduce so valuable an element of brain material?

I am greatly pleased that our society is agitating the subject of restoring the shad to the people on the North Branch, not as a luxury for the few, but for all, cheap and faithful, and coming at a season of the year when most desirable as food, for nowhere on this continent were finer shad found than those taken from the North Branch of the Susquehanna River.

The long run of the pure, cold, spring-made waters of the Susquehanna made them large, hard, and fat, nowhere equaled.

Why must we be denied this luxury now, when other streams are being filled with fish?

Very truly yours,

C. DORRANCE.

[From the Tunkhannock Republican, April 15, 1881.]

SHAD—HOW THEY WERE CAUGHT IN YE OLDEN DAYS—THE FISHERY COMPANIES—THE REASON SHAD DO NOT NOW INHABIT THE UPPER WATERS OF THE SUSQUEHANNA.

We are indebted to Hon. P. M. Osterhout for the following interesting history of early shad fishing in the Susquehanna. It was written by him for the Historical Society of Luzerne County, by the society's request:

The first shad caught in the Susquehanna River was by the early settlers of the Wyoming Valley, who emigrated thither from Connecticut.

The food of the early emigrants was, in the main, the fish of the streams and the game on the mountains. The first seine in the valley was brought from Connecticut, and upon the first trial, in the spring of the year, the river was found to be full of shad. These emigrants had settlements along the Susquehanna from Wyoming to Tioga Point, now called Athens; and each neighborhood would establish a fishery for their own accommodation. It was generally done in this way: Say, ten men (and it took about that number to man a seine) would form themselves into a company for the purpose of a shad fishery. They raised the flax, their wives would spin and make the twine, and the men would knit the seine. The river being on an average forty rods wide the seine would be from sixty to eighty rods long. The shad congregated mostly on shoals or the point of some island, for spawning, and there the fisheries were generally established. Shad fishing was mostly done in the night, commencing soon after dark and continuing until daylight in the morning, when the shad caught would be made into as many piles as there were rights in the seine. One of their number would then turn his back and another would touch them off, saying, pointing to a pile, who shall have this and who shall have that, and so on until all were disposed of, when the happy fishermen would go to their homes well laden with the spoils of the night. Between the times of drawing the net, which would be generally about an hour, the time was spent in the recital of fish stories, hair-breadth escapes from the beasts of the forests, the wily Indian, or the Yankee production, the ghosts and witches of New England.

As early as 1800 George Miller and John McCord moved from Coxestown—a small town on the Susquehanna, about five miles above Harrisburgh—up the river in a Durham boat, and, bringing with them a stock of goods, located at Tunkhannock, where they opened a store. They were both young men and unmarried. In the spring of the year they dealt quite largely in shad, the different fisheries of the neighborhood furnishing them with large quantities for curing and barreling. Shad were plenty but salt scarce. There was no salt except what was wagoned from the cities or from the salt works at Onondaga, N. Y., and it was not unusual that a bushel of salt would purchase one hundred shad—in fact it was difficult to procure salt to cure them. At this time the German population in the lower counties of the State had not learned the art of taking shad by means of the seine.

There were then no dams or other obstructions to the ascent of the fish up the river, and large quantities of the finest shad in the world annually ascended the Susquehanna, many of them when taken weighing from six to eight pounds each. The distance being so long (about 200 miles) from tide water to the Wyoming Valley the flavor of the shad was very much improved by contact with fresh water. The Susquehanna shad were superior to the Delaware, the Potomac, the Connecticut, or the North River shad. The reason generally given was their

being so long in fresh water, which imparted to the fish a freshness and richness not found in the shad of other rivers. Then none but the strong healthy shad could stem the current and reach the upper waters of our beautiful river.

Miller and McCord cured and put up annually shad for the market. They boated down the river a large quantity for the times, and sold to the people on the lower Susquehanna. They also boated shad up the river as far as Newtown, now Elmira, from thence they were carted to the head of Seneca Lake, a distance of twenty miles, and from there were taken to Geneva and other towns, in what was then called the Lake country, and sold.

There was a fishery on the upper point of the island opposite McKune's Station, on the Lehigh Valley Railroad. This island was known by the early settlers as one of the Three Brothers. There was also an important fishery at Hunt's Ferry, about five miles above Tunkhannock. Here large quantities of shad were caught every spring. This fishery was owned by twenty rights, ten fishing at alternate nights. There was also another fishery at Black Walnut, below Skinner's Eddy. At all these fisheries more or less Oswego bass were caught, called down the river Susquehanna salmon, a most excellent fish, but they are now nearly extinct. The river ought to be restocked with that same species; they are a fine-flavored fish, solid in meat, and grow to 12 or 15 pounds in weight. The late George M. Hollenback, esq., of Wilkes Barre, told me that this bass was brought from the Oswego Lake and put into the Susquehanna at Newton, now Elmira. They were called by the old settlers swager bass. Since the building of the dams across the Susquehanna there have been no shad caught above the Nanticoke dam. These dams also largely obstruct the passage of bass and other food fish up river. The Susquehanna is really one of the finest streams for fish in the United States—the water pure, the bottom rocky and pebbly, affording abundant means for spawning and rearing the young fish. The obstruction to the free passage of fish up the river ought to be removed.

Maj. John Fassett, of Windham Township, one of the oldest citizens of that town, as was his father before him, was written to on the subject of the early shad fisheries from Hunt's Ferry to Wyalusing. He mentions the one at Hunt's Ferry; also, at Black Walnut, and others at different points up the river as far as Wyalusing. He says his father owned a right in the fishery at Black Walnut, which he valued at $100; here were large numbers of shad caught, which were valued at 6 cents each, and would weigh from 6 to 12 pounds each. The largest one he saw weighed was 12 pounds; the writer hereof thought he had got it pretty steep as to weight, but he was beaten by Jennison Harvey, esq., an old resident of Plymouth, Luzerne County, now of Wilkes Barre, who says that he saw a shad weighed—on a bet—that was caught in the river in the valley and that it weighed 13 pounds. Some folks will think it a fish story. Harvey has decidedly the advantage of Major Fassett, as he had the last say.

[From the Berwick Independent, March 10, 1881.]

SHAD FISHING IN THE SUSQUEHANNA—WHAT MR. GILBERT FOWLER KNOWS ABOUT IT.

The Wyoming Historical and Geological Society having requested Mr. Gilbert Fowler, of this place, to give any information he may possess concerning the shad fisheries of the Susquehanna, the following has been furnished by him:

BERWICK, PA., *February* 23, 1881.

MY DEAR SIR: Your letter, requesting me to give your society my recollections of the shad fisheries in my early days, was duly received. I will do so with great pleasure. But first let me premise: I was born February 23, 1792, in Briar Creek Township, Northumberland County, now Columbia. I write or dictate this letter on my eighty-ninth birthday. I have lived near the Susquehanna River ever since I was born. My knowledge and recollections about the shad fisheries extend from Wilkes Barre to old Northumberland. The first shad fishery near my home was Jacob's Plains. This was located just above the town of Berwick, and one of the most productive fisheries on the river. Here I have assisted in catching thousands upon thousands of the very finest shad weighing eight and nine pounds. The next nearest was Tuckaho fishery, situated about one and a half miles above Berwick, on the same side of the river. At this place many thousands were caught night and day in early spring. The next was down the river about six miles from Berwick. This was the fishery of Benjamin Boon. At this fishery I have known so many caught that they were actually hauled out by the wagon load on Benny Boon's farm for manure, so plenty were they. The next fishery was that of Samuel Webb, located about four miles this side of Bloomsburg. This was an immense shad fishery. From the banks of the river at this fishery could be seen great schools of shad coming up the river when they were a quarter of a mile distant. They came in such immense numbers and so compact as to cause or produce a wave or rising of the water in the middle of the river extending from shore to shore. These schools, containing millions, commenced coming up the river about the 1st of April and continued during the months of April and May. There was something very peculiar and singular in their coming. The first run or the first great schools that made their appearance in the early spring were the male shad—no female ever accompanied them. In about eight or nine days after the male had ascended the river, then followed the female in schools, heavily laden with eggs or roe. Those were much the largest and finest fish, and commanded the highest price. Those shad that were successful in eluding the seine and reached the hatching ground at the headwaters of the Susquehanna, after depositing their eggs, returned again in June and July, almost in a dying condition, so very poor were they. Many died and were found along the river shore. The young shad would remain

at their hatching places till late in the fall when they would follow the old shad to the salt water. During the summer they would grow from three to four inches in length. The Susquehanna shad constituted the principal food for all the inhabitants. No farmer, or man with a family, was without his barrel or barrels of shad the whole year round. Besides furnishing food for the immediate inhabitants, people from Mahantongo, Blue Mountains, and, in fact, for fifty miles around, would bring salt in tight barrels and trade it for shad. They would clean and salt the shad on the river shore, put them in barrels, and return home. The common price of shad was three and four cents each. Besides shad there were many other kinds of food fish. The most noted among them was the old Susquehanna salmon, weighing as high as fifteen pounds. These salmon were considered even superior to the shad and commanded a higher price. They were caught in seines, on hooks and lines, and were the sport to the gigger at night. Nescopeck Falls, directly opposite Berwick, near where the Nescopeck Creek empties into the river, was a noted place for salmon fishing with hook and line. Men standing on the shore with long poles and lines would often, in drawing out the fish, lodge them in the branches of the trees, giving them the appearance of salmon-producing trees. The shad fisheries, which I have alluded to, were not common property. The owner of the soil was the owner of the fishery, and no one was allowed to fish without a permit. The owners of the fishery also had the seines, and when not using them they would hire them out to others and take their pay in shad. The seiner's share was always one-half the catch. Shad were caught both night and day in seines. At the Webb fishery I have known eleven and twelve thousand shad taken at one haul. These fisheries were always considered and used as a source of great pleasure, value, and profit, and everybody depended on them for their annual fish and table supply. It was considered the cheapest and best food by all. Immediately after the erection of the river dams the shad became scarce, the seines rotted, the people murmured, their avocation was gone, and many old fishermen cursed Nathan Beach for holding the plow, and the driver of the six yokes of oxen, that broke the ground at Berwick for the Pennsylvania Canal. The people suffered more damage in their common food supply than the State profited by her "internal improvement," as it was called. Although eighty-nine years old to-day, I still hope to live long enough to see all the obstructions removed from one end of the noble Susquehanna River to the other, and that the old stream may yet furnish cheap food to two millions of people along its banks, and that I may stand again on the shore at the old Webb fishery and witness another haul of ten thousand shad. All of which is most respectfully submitted for the consideration of the honored society which you have the honor to represent.

GILBERT FOWLER.

HARRISON WRIGHT, Esq.,
Secretary of the Wyoming Historical
and Geological Society, Wilkes Barre, Pa.

WYALUSING, *March* 14, 1881.

SIR: Your communication of the 26th ultimo was duly received, and in reply to your request for information relative to the shad fisheries of this vicinity, I am able to state the following facts, answering your questions in detail:

Commencing at Standing Stone, about 10 miles from Wyalusing village, and reaching down the road from that point to the Wyoming County line, there were five "old shad fisheries," viz:

(1) The "Standing Stone fisheries." William Hank, Benjamin Brown, Cornelius Ennis, and Benjamin Bennet owned this. It was a valuable property, worth at that time from three to four hundred dollars a year. There were from three to four thousand shad caught there annually. They caught no rock or striped bass, sturgeon, or herring there or at other fisheries in this vicinity.

(2) The Terrytown fishery. This was owned by Jonathan Terry, William Dodge, Edmund Dodge, Samuel Wells, and John Taylor, and was of about the same value as that at Standing Stone.

(3) The Wyalusing fishery, owned by John Hollenback, Benjamin Stalford, Joseph Stalford, and John Stalford. This fishery was worth about $250 a year, with a "catch" of from two to three thousand shad.

(4) The next was the "land" fishery at the head of Ingham's Island. Joseph Ingham owned this, and it was worth about $200 a year.

(5) Next was the Brown Town fishery, owned by Humphrey Brown, Allen Brown, and Samuel Brown, and was worth about $150 per annum.

(6) The next and last was called the "Bend fishery," and was located near the line between Bradford and Wyoming Counties. James Quick and James Anderson owned this, and it was worth about $150 a year.

The stoppage to the emigration of shad to this vicinity was a great loss to the people. For nearly two months every year the people for from 15 to 20 miles, from the poor, were bountifully supplied, and I should consider it a great benefit if the fisheries could be restored.

Respectfully,

NELSON B. HOLLENBACK.

MARCH 3, 1881.

DEAR SIR: Yours of the 26th ultimo, making enquiry in relation to shad fisheries near Wyalusing, is at hand. I spent many a pleasant day in my boyhood with the men who ran the shad fishery in the Susquehanna, near where I now live. I could easily fill a small volume with a description of the varied amusements and merriments of those by-gone days, but that would hardly be what you are after. This fishery was about two miles above the mouth of the Wyalusing Creek, at the place we now call Terrytown; formerly all was Wyalusing along here. There were other fisheries above and below us, but this the only one I have any personal knowledge of. The proprietors were Jonathan

Terry, esq., Maj. John Horton, sr., Maj. John Taylor, Edmund Dodge, Maj. Justus Gaylord, Gilbert Merritt, William Crawford, and William Wigton. Year after year, for a long time, these men operated this fishery, generally taking the month of May and a part of June of each year, always regaling themselves with a little good *old rye*, and having a fine sociable every night when counting off and distributing the shad caught during the day. Occasionally they sent substitutes, but the fishery never changed proprietors. Some seasons they caught largely; others not so many. I well recollect one draught, or haul, when they caught 500, but ordinarily 20 to 50 at one drawing of the seine was considered good. The average per day, according to the best of my recollection, would be about 150.

People came from the eastern part of the county, then just settling, up to Wyalusing, as far or nearly as far as from Montrose, to buy shad. The trade was quite large. Some of the time maple sugar was quite a commodity, brought down to exchange for shad.

Very few of any other kind of fish except shad were ever caught Occasionally a striped bass, large pickerel, carp, sunfish, mullet, sucker, or a bull-head was taken; no small fish, as the meshes of the seine were large enough to let them through.

The shad were worth from 10 to 25 cents each, according to size. I have seen them caught here weighing nine pounds; ordinarily their weight was from four to seven pounds. If we could have that old shad trade here again it would make us all, if not rich, merry again. But very few are now left among us who saw those glorious old fishing days. The fishing for black bass of these days does not begin with those old fishing days.

I cannot recollect of but one fishery between Wyalusing and Towanda, and only two between Wyalusing and Tunkhannock.

Hastily, but very truly, yours,

GEORGE F. HORTON.

FISH IN THE SUSQUEHANNA AT WYOMING.

In accordance with your request I will give you a few items in regard to fish in the Susquehanna, in the early times.

The present inhabitants of Wyoming have but a faint idea of the value of fish to the early settlers. They performed as important a part at Wyoming as they have in the history of all new settlements. A careful study of the advance of immigration and the settlement of new regions shows that those settlements have been guided and controlled by the streams and waters in which fish abounded, and hence were made along their shores. Fish furnished the people a plentiful and healthful supply of food, easily attainable, until the forests could be hewn down, clearings made, crops raised, and cattle could increase and multiply.

It is unquestionable that the early progress made in settling up of

our country was due in a large measure to the presence of fish, which furnished food in absolute abundance in the midst of desert lands; and it would be as idle to attempt to disparage the value in the economy of those times as it would be to prove the value now beyond the mere mention of the fact.

The fish that attracted the most attention and were the most highly considered in the early times were shad. The knowledge of these excellent fish in the Susquehanna, at Wyoming, has become almost entirely historical, if not entirely so. But few persons, now resident at Wyoming, have a personal knowledge of the shad fisheries there and their value to the people in the early days, and hence some of the stories told of the immense hauls of them made in "ye olden time" seem to the present generation more fabulous than real.

That we may the better understand the subject, I will give extracts from the writings of strangers, and then conclude with an account or two of our own people and what I myself have seen.

In 1779, when General Sullivan passed through Wyoming on his western expedition against the Indians, portion of his advance were located at Wyoming from May to the last of July. Many of his officers kept diaries, in which they noted their movements from day to day and touched slightly upon such objects of interest as attracted their attention. I will give a few extracts from these diaries relating to fish at Wyoming.

Dr. Crawford in his diary, under date of June 14, 1779, says:

"The river at Wyoming abounds with various kinds of fish. In the spring it is full of the finest shad. Trout and pickerel are also plenty here."

George Grant, under date of June 23, says:

"The Susquehanna River affords abundance of fish of various kinds and excellent."

Dr. George Elmer, under date of 23d June, says:

"Spent chief part of the day in fishing. Salmon, trout, suckers, bass, and common trout are plenty in the river, of which we catched a number with a seine."

Daniel Gookin, under date of 28th June, says:

"The river Susquehanna, on which this lies, abounds with fish. Shad in great plenty in the spring, as they go up to spawn. The shores are covered with these fish which have died up the river, through their too long stay in fresh water."

There were some 25 or 30 what we called shad fisheries within the bounds of old Wyoming. Every available point for casting out and hauling in a seine on the beach, whether on an island or on the mainland, was used as a fishery, and had its owners and its seine. The average number of shad taken at each of these fisheries in a season was from 10,000 to 20,000, beside other fish which were caught before and after the shad made their migration.

It is given on good authority that 10,000 were caught at one haul at the Stewart fishery, about midway between Wilkes Barre and Plymouth, about 1790. This was called the widows' haul.

The settlements, after the massacre of July 30, 1778, had so many widows and fatherless children among them, that they made special provisions of bounty for them on many occasions, which were wrought out in such a way as neither to give offense nor to convey a sense of undue obligation.

Among the arrangements of this character was that of giving one of the hauls at each fishery, every year, to the widows and fatherless of the neighborhood, and hence called the widows' haul. By common consent it was agreed that the widows should have a haul made of the first Sunday after the season of shad-fishing commenced, and they were to have all caught, whether more or less.

This big haul was made on Sunday.

At the rate I have given, which is made up more from general information upon the subject than from statistics, the number of fish caught annually was about a half a million, which at 30 cents each would make $150,000.

Were the Susquehanna as well stocked with shad to-day as it was a hundred years ago, our keen and hungry fishermen would easily double the catch, and still, like Oliver Twist, "cry for more."

I recollect seeing, in the spring of 1826, a haul made in a cove at the lower end of Wintermoot Island, west side, numbering 2,800 shad. When thrown out they whitened a large space upon the shore.

Being the first haul of the season, the fish were largely distributed among the people, and even after that, my grandfather had a half barrel for his right as owner of the seine and fishery.

About 1831 or '32, in the fall, an unusual catch of eels was made in a weir on the east side of Wintermoot Island. During one day and night 2,700 of them were caught, while many escaped from want of means to handle them and take them away as fast as they came in. Another day and night 900 of them were caught, when the basket floated off with the high water.

I herewith give you copies of two papers in my possession bearing upon the shad-fishery question. It will be seen by one of them that the price of shad in the early times was 4*d.* or 4⅓ cents each; quite a different price from what they sell at in our day.

Tear the dam from the Susquehanna and we shall have plenty of shad, if not at 4*d.* each.

Yours,

S. JENKINS.

"Be it known that I, Peter Shafer, have sold all my right in and unto all my right in the Dutch fishery, so called, below the Nanticoke Falls, so called; for and in consideration thereof I, Jacob Cooley, do promise

to deliver Seventy shad, unto William Miller, on account of me, the said Peter, on or before the 20th May instant; or otherwise settle with said Miller for what I am indebted for my part of said Seine, and likewise the said Cooley is to deliver Six gallons of Whiskey unto the said Peter, between this date and *Weat* harvest.

"Witness our hands this 14th day of May, 1800.

"PETER SHAFER.
"JACOB COOLEY."

"James Fox holds an order for 725 shad drawn by George Frazer on James Stewart, date April 27.

(Indorsed on the back in these words:) Credit for 350 shad received by me. David Morgan.

(Endorsed:) Copy of Frazey's order. Henry Thomas charges the Estate with 4*s*. 8*d*., paid in Rye. Paid.

No. 40—

	725	
Rec'd	350	
	375 shad at 4*d*.	
	125 *s*.	
£6	5*s*.	$16 67
Interest on same,		9 50
		26 17 (£ = $2.67)

PITTSTON, *March* 22, 1881.

DEAR SIR: Yours of the 15th instant came to hand. I feel interested in your Historical Society, having years ago, with the late Dr. Josiah Blackman, been an invited guest to an anniversary dinner of your society, and have written some reminiscences for the newspapers; but I fear, never having been a fisherman, I cannot afford you much valuable information.

I inclose you a card with Esquire Thomson's address. Though a few years my junior, yet I know that, in those days I shall speak of, he was quite a fisherman. I understand from his son-in-law, H. C. Dewey, that his memory and intellect are good.

I see by your correspondent's—G. Fowler, of Berwick—published letter that he tells a *big fish story*. I incline to think, however, that it is true. I recollect when I lived with my grandfather, in what is now South Wilkes Barre, perhaps 1798 or 1799 of last century, the great haul of shad at Nanticoke was made. I believe there were nine or ten thousand taken. A number of seines were engaged in it, and lawsuits were the consequence. Salt was scarce and dear. Northampton men came with pack-horses loaded with salt, and returned loaded with shad. I bought and kept the public house that had been kept by John Courtright on the Plains, Wilkes Barre Township, in the spring of 1815. There

were then two fisheries between us and the Pittston Ferry—one at Monocacy Island landing, on the shore of Mr. Samuel Cary's land, the other starting at or near the Wintermoot Island and landing above the ferry at Blanchard's. That season I got my supply at the upper fishery; the first day's attendance was a "blank" day—few or no fish. The large schools of Mr. Fowler's times were dwindled greatly, caused undoubtedly by the numerous fisheries that existed below, and the destruction of the young shad by the many eelweirs, in their descent to the ocean in the fall. My time was too valuable to attend on blank days. I left money with Mr. Joseph Armstrong, and he sent me my supply when successful. The next season (1816) the difficulty that had existed between the fishermen at Monocacy (twelve in number) and Mr. Cary, the owner of the land, by giving him the thirteenth share settled the difficulty, and ever after I got my supply from the fishery until the canal dams cut off our supply totally. It was a serious damage and inconvenience to us, as markets for fish and meat did not exist then as now. The Susquehanna shad had a far more delicious flavor than any we get now.

General Isaac Bowman, Samuel Moffit, and some of our Plains neighbors, having secured a landing on the Nommock at the foot of Monocacy Island, fitted up a fine seine and necessary boats (canoes) and caught half a dozen shad, having fished twice as many days. I shared two, having found the whisky (before my temperance days); others outbid me, determined to taste the good of their labors. I fatigue much in writing, being in my ninetieth year.

Respectfully yours, ELISHA BLACKMAN.

LEE, LEE COUNTY, ILLINOIS, 4–12, 1881.

DEAR SIR: I was born at Pittston in 1796. My father's farm lay along the side of the Susquehanna River. I lived on the farm fifty-one years. In regard to the shad fishing, as I grew up to manhood I fished many days in the shad-fishing season of the different years. The first run was the male shad—not near as good as the female. After catching the first run then, if we could have a rise of water then came the female—a far better quality. The female put for the headwaters of the river, and there would spawn; then the old fish would come back down the river, and the wind would often drive them on the shore, and they would lay there rotting till they stunk. People used to come down from toward Easton, Northampton County, and bring whisky and salt, and trade for fish; also from the upper part of old Luzerne County, bringing maple sugar to trade for shad. One man by the name of Taylor bought fifteen and put them in a sack after they were cleaned, shouldered them and walked off with them. I have known upwards of a thousand caught in one day on the point of the island. As to the localities of the fisheries, there was one at Falling Spring, about four miles from where I

lived, another on the point of Wintermoot Island, and the next on the side of the island between two and three miles from where I lived. They drew out on the beach of Samuel Cary's farm; another just below that, I think, drew out on the farm of Crandall Wilcox; another just below the falls. Please excuse me now, as I have done as well as my memory will allow me to. We have done no fishing since Nanticoke dam was built.

With regards, ISAAC THOMPSON.

INTERVIEWS, &c.

Steuben Butler, a son of Col. Zebulon Butler, who led the patriots at the battle and massacre of Wyoming, 1778, says:

I was born 1789; remember the old shad fisheries in the river here very well; was not a fisherman myself; after the run of shad had started I used to get in a boat and row up to the fishery and purchase my supply of shad and bring them down and salt them away. The price varied according to the abundance of the shad, some seasons being less expensive than others. As I recollect it, the Pettibones used to have charge of the fishery above Wilkes Barre.

Dr. Charles F. Ingham says:

I remember the old shad fisheries in the North Branch, particularly the Butler fishery, which was on the bar opposite and a little above Union street, Wilkes Barre. Nanticoke dam was commenced in 1828 and finished in 1830, and I recollect that that ended our fishing. Although I saw shad caught below the dam by hooks attached to poles—think it was the year the Shamokin dam went out—yet I have never heard tell of or seen shad being caught since that time above the dam. The shad, as I remember them, were very fine and particularly large. I have seen the beach, after the drawing of the seine, for a hundred feet absolutely alive with flapping shad, each one reflecting the sunlight like a burnished mirror. I recollect having the salted and smoked shad during the fall and winter, and fine delicacies they were.

After our shad fishing was cut off, a great number of salt shad were brought from Philadelphia and other points, meeting with ready sale, on account of general knowledge of their delicacy. I believe that at one time the people knew more of salt shad than they now know of salt mackerel, and more of smoked shad than now of smoked salmon.

I believe that a proper shad-way could now be put in the Nanticoke dam sluice-way or chute at an expense not to exceed $10,000, and probably for less, without interfering with navigation.

Mr. Isaac S. Osterhout says:

In 1820 or 1821, we caught shad in very large quantities at Black Walnut Bottom. I remember well I went with Captain ——— ——— to Salina, New York State, after salt, as we had run out of that article

very early in the season; he had a load of whetstones and I a load of shad. I could have easily gotten rid of my shad on the first day had it not been that the Captain and I had agreed that the whetstones should sell the shad, and *vice versa*. So it was several days before we got our loads of salt, as the whetstones went terribly slow.

In 1822 and 1823 I was at Hunt's Ferry, where the shad were plenty. I came to Wilkes Barre in 1830, the early part of the year—the same year the Nanticoke dam was finished; do not recollect of any shad being caught after that. I recollect of a Mr. Water Greens, who came from New England and settled at Black Walnut Bottom, giving twenty barrels of shad for a good Durham cow.

Miss Mary Coates says:

I was born in 1803; came to Wyoming Valley to live in the year 1823. I remember very well the catching of shad in large numbers by the inhabitants and the cleaning of them along the river shore. I remember, too, that the country people came in crowds during the season from miles away and returned home laden with fish. I remember the anger of Gildersleeve's negress one day, when it was said that Gildersleeve had made her wade out into the river after shad heads. The circumstance was as follows: While cleaning the shad she had cut off the heads and placed them on a board, saving this most delicate part of the fish for herself, and while she was busy the board, covered with shad heads, was either pushed by some one, or drifted out into the river, when she waded out to get it. Do not know anything of the numbers caught. The people had shad from spring to spring. I do not remember of any shad being caught after the Nanticoke dam was put in.

Capt. James P. Dennis says:

I remember the old shad fisheries in the river. There was one just below the bridge at Wilkes Barre, drawn out on the opposite shore; this was called the Bowman fishery. I recollect once holding the shore brail of the seine at this point, when William Alexander held the river brail. There was a fishery on Fish's Island, about three-quarters of a mile below the bridge.

Jameson Harvey says:

I was born in 1796. I remember the old shad fishing in the North Branch of the Susquehanna River very well. James Stewart had a fishery opposite my place. The big haul was made at Fish Island fishery. I recollect it very well; they didn't know how many they caught. After all were disposed of that could be, the rest were thrown on the fields, and pretty near stunk us to death; they were landed on the point of the island. There were two seines on Fish Island, one owned by Nanticoke parties, the other by Buttonwood parties, who took turn about fishing. The Mud Fishery was at Steele's Ferry; they drew out on Shawnee side. The Dutch fishery was below the dam on Croup's place. Below Hunlock's Creek was another, that was called a mud

fishery. There was a fishery at Shickshinny. When the big haul was made the shad sold for a cent a piece; they sold as many as they could; there wasn't salt enough. In those days they didn't salt down so much pork; they depended upon the shad they caught; they gave the poor a chance after they got all they wanted. People on the West Branch used to own an interest in the Hunlock fishery, and a Mr. McPherson used to come in a boat to get their fish and take them back. They used to come from Easton bringing salt, with which they used to buy fish; you could get one hundred shad for a bushel of salt. Nanticoke dam was commenced in 1828 and finished in 1830. I only recollect of one shad being caught above the dam since it was put in, and that was on the flats after a big freshet. The people used to go off the bars with as many shad as they could carry; they came in from all around in crowds; they used to camp and salt their fish down on the banks of the river. Mr. McPherson used to take his boats back to the West Branch loaded. He traded off cider, oil, and whisky. At the time the dam was put in, shad were selling for 10 cents and 12 cents each. Widow Stewart used often to take in $30 or $40 of a night for her share of the haul.

Hunlock's, Dutch, and Mud fisheries were night fisheries. Stewart's and Fish Island were day and night fisheries. Farmers hauling grain to Easton often hauled back hundreds of bushels of salt.

Boats coming up the river used to bring leather, cider, oil, salt, and iron; going back they would take shad.

McPherson and Hunlock owned the Hunlock fishery and had a large fish-house. Hunlock got as his share from five to six hundred dollars per year, besides all the shad he could use. We used to have shad until shad came again.

The owners of fish-houses used to have arrangements so that when they run out of salt they could dry and smoke the shad, as they now do herring and salmon. Some of the shad used to weigh 8 or 9 pounds. I saw one weighed on a wager turning the scales at 13 pounds; about seventy or eighty would fill a barrel. The shad improved very much coming up the river, those caught in this valley being very much larger and finer than those caught at Columbia. I remember when Shamokin dam went out, the shad came up to our dam and were caught.

The following is an extract from Miner's History, p. 209:

April 21, 1778.—At a Town meeting prices were set on articles of sale, &c.:

Winterfed beef, per lb	7*d*
Shad, a piece	6*d*
Tobacco, per lb	9*d*
Eggs, per doz	8*d*

[From the Susquehanna Democrat.]

1818, *April* 17.—"Newark, N. J., April 7th, shad fishing. On Wednesday 3 shad were caught in the river Passaick. A pair of them weighed

eleven pounds, and were sold to one of our public innholders at a shilling a pound. A solitary one was caught about 2 weeks before & sold to the same innkeeper."

1819, *May* 14.—"Shad are this season taken in unusual numbers; they have been sold in Philadelphia as low as $4.50 per hundred, & at the Potomac fisheries as low as $3."

1820, *April* 21.—"At Alexandria shad *is* selling for $2.50 a hundred and at Philadelphia they are selling for $3. In Wilkes Barré, notwithstanding the scarcity of money, they are held at $18.75."

1822, *April* 26.—"We congratulate our friends on the prospect of soon obtaining a supply of fresh shad; about sixty were caught here on Wednesday (24th), and yesterday (25th) upwards of three hundred. We learn that at Berwick they are caught in abundance."

The above was all I could find in a file of 14 years, 1810–1824, bearing upon shad. In the Federalist, printed at the same time, nothing was found.

H. W.

Know all men by these presents that I, Silas Smith, of the township of Newport, county of Luzerne, and State of Pennsylvania, have sold unto Caleb Wright, of the District of Huntington, in the county and State aforesaid, one equal half share of a fishery on the lower end of my farm, for the consideration of twenty pounds ($53.33) lawful money of Pennsylvania to me in hand paid, the receipt of which I hereby own and acknowledge. I hereby bind myself, my heirs, executors, administrators, or assigns, and every of them, by these presents, to warrant and forever defend unto him, the said Caleb Wright, his heirs, executors, administrators, or assigns, the one-half of said fishery to the only proper use and benefit of him, the said Caleb Wright, his heirs, executors, administrators, or assigns.

In witness whereof I have hereunto put my hand and seal, this fourteenth day of May, in the year of our Lord one thousand eight hundred and four—1804.

[SEAL.] SILAS SMITH.

Witness present:

BETSY MILLER,

MARGERY SMITH.

[From Miner's History of Wyoming, p. 141.]

"The month of February, 1773, had so nearly exhausted the provisions of the Wilkes Barre Settlement, that five persons were selected to go to the Delaware, near Stroudsburg, for supplies. * * * The distance was fifty miles, through the wilderness, &c. * * * The men took each an hundred pounds of flour, and welcome was their return to their half-famished friends at Wilkes Barre. Never was an opening spring, or the coming of the shad, looked for with more anxiety, or hailed with

more cordial delight. The fishing season, of course, dissipated all fears, and the dim eye was soon exchanged for the glance of joy and the sparkle of pleasure, and the dry, sunken cheek of want assumed the plump appearance of health and plenty."

REMARKS ON THE SCARCITY OF MALE AND GRILSE SALMON IN THE RIVERS OF ONTARIO, CANADA.

BY SAMUEL WILMOT.

[Letter to Prof. S. F. Baird, U. S. Commissioner, Fish and Fisheries.]

DOMINION OF CANADA—PISCICULTURAL ESTABLISHMENT, FOR THE ARTIFICIAL PROPAGATION OF SALMON, WHITE-FISH, TROUT, BASS, ETC.

NEWCASTLE, *October* 30, 1880.

DEAR SIR: I desire to acknowledge with many thanks the receipt of some 50,000 California salmon eggs. They arrived here in first-class condition, and are now all hatched out. I also notice with much pleasure the arrival at New York, and shipment to Europe, of a very large lot of these ova, all of which were reported to be in very fine condition. This success in your efforts in connection with fish-culture, whilst it must be very gratifying to yourself, is likewise pleasing to me, and no doubt to all others engaged in the industry of artificial fish culture.

I have to record a most peculiar circumstance in relation to our Ontario salmon this autumn. I speak more particularly of those which have come into my stream here. The same falling off in numbers is felt here as has been the case in all the rivers and streams on the Atlantic coast. My reports received from the several officers in charge show a wonderful falling off. At the Saguenay, where formerly our requisite supply of some 300 parent salmon were easily obtained in a few weeks in June and July, only some 75 could be captured during the whole season; on the Restigouche, the most famous salmon river we have, only some 600,000 salmon ova could be gathered, whereas in former years no difficulty was experienced in getting one and a half to two millions. At the Miramichi and Halifax nurseries the result is not known; no reports have as yet come in, but I fear a similar falling off will take place there as well. In connection with the reduced numbers of salmon at this hatchery, strange to say, only three males have yet been found in the stream; all that have been captured or have entered the reception house are immensely large females. We have enough of these on hand at present to give us 250,000 eggs, but we have not, nor can we find in the whole stream, a single male fish to impregnate these eggs with, should we strip them. What we shall do puzzles me very much; add to this the fact that the season is about over for fish to enter the stream. To-day I went down the creek with one of my men and caught some 18 magnificent female fish on the beds in the open stream in broad day-

light, but could not find one male. This has been the case since the first entrance of the salmon this fall. There are any amount of beds; in fact, on many of the gravel beds the bottom of the creek is literally ploughed up with the workings of these salmon. Another peculiarity is that not a single grilse has been seen (with the exception of one California grilse taken last night). In the fall of 1878 salmon of both sexes and grilse were very numerous, quite equal to the olden times some thirty-five or forty years ago. In 1879 they fell off very largely in numbers, and this season they are very much reduced from last year, with the peculiarity of all being large females, and no grilse. I mention these circumstances for your information, and they will, no doubt, appear to you as being very extraordinary. I can hardly venture to ask you for a cause, or even the theory of a cause, for this peculiarity with my fish. My only hopes are that when Professor Hind hears of it he, with his love in relation to salmon (particularly the biennial and summer-spawning ones), will, no doubt, incubate some theory why, and how, these phenomena have occurred.

I am also getting puzzled in mind about your California salmon; they are also turning a cold shoulder to me. The record, this season of 1880, is as follows: In April last my son caught a very beautifully formed one in the stream here whilst fishing for some suckers. He was about three pounds in weight; I have him yet. He has been kept in a small tank of spring water along with some trout, but we have never seen him eat anything yet. He is looking a little thin just now. One small trap-net was set out in the lake this season nearly opposite my stream, and during my absence the fishermen reported that about half a dozen small Californias were taken, from four to six pounds. About ten days ago a female California was caught in this creek (spent); length, 28 inches; she was terribly battered up; and last night I caught a small grilse; they were the most miserable specimens of fish I ever saw. Judging from what I have read of the "Quinnat" (having never seen a full sized adult), these two last mentioned specimens cannot belong to that class. I should say they must be more like the "*Salmo scouleri*," hooked-nosed salmon, or "*Salmo canis*," dog-salmon, as each of them has three sharp hooked-like teeth at the extreme end of both the upper and lower jaws. I have never seen fish with teeth so strangely shaped, nor so peculiarly placed in their mouths as these two fish have them.

Before closing this letter, might I ask as a favor, whether it would be possible for me to obtain from you a few carp. I have some ponds which were originally made for nursery ponds for young salmon, but finding that the temperature of the water rises so high in them in the summer, that the salmonoid family all die, I have thought of using them for carp. The water, to any extent, can be supplied from the main creek; the ponds cover some three acres or more, ranging from 2 to 4 feet deep. Should I succeed in getting a few carp, I would sink wells some 8 or 10 feet deep in them, in which the carp could sleep during the extreme cold in

winter. The water gets pretty warm in them in summer and a good deal of vegetable matter is produced in them, which I think would be well adapted for the growth of these fish. I have raised the gold fish or golden carp in one of them somewhat successfully. Being desirous of trying the German carp, I shall feel greatly indebted to you if I could get a few pairs through your kind instrumentality.

P. S.—If you would like a specimen of our Ontario salmon in the gravid state, I shall be greatly pleased to forward one or more to you. I can only promise you two females from the causes mentioned herein. Should you also like to have one of the *lacerated, emaciated* specimens of "Canadian Californias," I will send it also.

FISHERY NOTES FROM GLOUCESTER, MASSACHUSETTS.

BY S. J. MARTIN.

[From a letter to Prof. S. F. Baird.]

The net fishing is almost done for this winter. There are only three boats fishing with nets. Those that have nets are doing well, and those who have lost them in the storm will not get any more this winter, as the time is getting short for net fishing. The nets which the boats had in the first part of the winter are used up. Nets will not last more than three months when they are down all the time; if they were taken up every morning, as they are in Norway, they would last two winters.

We have no news from the four missing vessels—schooner Edith M. Pew, Captain Corliss; schooner Paul Revere, Captain Bently (these two vessels were haddocking); schooner Bessie W. Somes, Captain Wright, one of the halibut catchers; schooner Charles Carroll, one of the vessels that went to George's. These four vessels are given up as lost; they had 51 men. I hope that is all. The halibut catchers have done poorly. The last three vessels that came in did very well; they got 40,000 pounds each. The George's vessels bring in small fares. The fish so far on George's are very large—the largest that have been caught for eight years. There are no school fish yet. Herring are abundant—five loads are in the harbor, selling at 75 cents a hundred. All the Newfoundland vessels are home; they all brought full loads. The three fish* mentioned were caught in a cod gill-net in Ipswich Bay. They were busters—three female fish with no spawn in them.

I have not much news to write. The fishing business looks well for Gloucester the coming year. Very few fish or mackerel in the market.

GLOUCESTER, MASS., *February* 27, 1882.

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*Copy of extract (*from newspaper*) accompanying Captain Martin's letter.*—"Three mammoth codfish were landed at Rockport last week by schooner Alabama, weighing respectively 97, 93, and 70 pounds."

FISH CULTURE FOR PROFIT.

By CHAS. E. HIESTER.

To grow fish for profit we select those kinds that are easily kept, which will not require to be fed artificially,—such kinds, in fact, as will feed themselves. Fortunately there are quite a number of varieties from which to select; but the common catfish now heads the list as a profitable market fish and water properly prepared and stocked with them yields a larger revenue than several times its area of the best farm land. This fish does not require a large supply of water, but can be cultivated in any quiet runway, or pond, and in water too warm for trout. It is very hardy; has no diseases of any kind; increases very rapidly and grows fast; is ready for market at a year old, and, having few small bones, always finds a ready sale at fair prices. In fact the demand for this sort of fish, a small pan-fish without bones, is practically unlimited. They live on the larvæ of insects and on the aquatic vegetation in the ponds and runways, and do not require any other food. No special breeding arrangements are required for them, and very little attention in any way, as compared with other varieties of fish. A peat soil is best, and will produce more fish to the acre than any other. Last winter from a single runway about a hundred yards long, in soil of this kind, nearly 20 bushels of marketable fish were taken, that sold for over a hundred dollars, and more than 50,000 small fry, in all stages of growth, remain in the waters.

An estimate of the value of an acre of pond surface may be made as follows: On proper soil 10 pounds weight of fish may be kept in less than 100 square feet of water, and the supply of food will be adequate; hence, an acre will afford over 42,000 feet of water, sufficient in capacity for more than 4,200 pounds of fish. This will give a supply of 82 pounds weekly. Such fish as may be grown in a pond sell at wholesale by the ton for 10 cents a pound, making an annual supply worth $840.

In connection with fish farming on level lands, fruit-growing and poultry farming can be carried on at the same time to good advantage. Parallel runways are cut through all the land it is desired to operate. The soil that is thrown out forms ridges or lands between the runways, about 2 feet above the level of the water, and on these lands plum and quince trees are closely planted. The curculio and other insects which make these high-priced fruits impracticable on the upland, here have no chance to work, and the result is perfect fruit. Experiments made during the past three years on a tract of land in Pennsylvania have shown a result on which we can base the following estimates:

Cost of preparing ten acres.

Embankment 1,800 feet, at 30 cents	$540	
Embankments 900 feet, at 20 cents	180	
		$720
Runways, 10,000 feet, at 8 cents		800
Water-gates, 3, at $10		30
Trees, 1,250, at 20 cents	250	
Planting	50	
		300
Extra labor, 4 men, at $1 per day		1,100
Tools, hoes, screens, &c		50
Total cost of preparing ten acres		$3,000

We are also able to get at the annual receipts and expenses, and we find that fish culture, instead of being the troublesome, fussy business it is generally supposed, in reality is the simplest of all the productive industries, and comparatively nothing remains to be done after the waters are properly prepared.

Annual receipts from ten acres.

10,000 feet of runway, 10 feet wide, 1 pound fish to 10 feet, at 10 cents	$1,000
85,000 feet of pond surface; 8,500 pounds fish, at 10 cents	850
1,250 fruit trees, plum and quince, at $1	1,250
Poultry and eggs	150
Total annual receipts	$3,250

Annual expenses.

Labor, 2 men	$600	
Tools, hauling, &c	20	
Total annual expenses		620
Net profits for one year on $3,000 invested		$2,630

Should the operations prove as successful on a large scale as on a small one, the receipts would be increased from one to one and a half times, which would make the annual net profits on ten acres considerably over $5,000.

For a new industry this is certainly a wonderful showing, and we are assured that the figures are rather within than over the marks.

F. F.

COD FISHING WITH GILL-NETS FROM GLOUCESTER, MASSACHUSETTS.

BY S. J. MARTIN.

[Letter to Prof. S. F. Baird.]

I will tell you last week's doings with cod gill-nets; fish caught in nets last week, 90,000 pounds. Fish are scarce. I think most of them have moved off the rocks. Most of the boats have had their nets up for repairs. They will all be set Monday. The nets rot very fast. The best thing to keep them from rotting is linseed oil. I saw some twine that had been put in a net last winter which is as good as ever this winter. Seven boats have their nets off here. That makes it better to have the nets in two places. They all have a better chance. I hope they will do better next week; if not, some will take trawls and give up the nets.

GLOUCESTER, MASS., *December* 31, 1881.

CODFISH CAUGHT NEAR CAPE CHARLES, MOUTH OF CHESAPEAKE BAY, IN 1834.

BY FRANCIS W. RYDER.

[Letter to Prof. S. F. Baird.]

I cut the inclosed* from the Boston Journal of February 16th instant. It would appear by this and other reports in the papers that codfish are seldom caught south of the New Jersey coast. The following is what a Cape Cod boy knew about codfishing near the capes of the Chesapeake forty-eight years ago.

In the summer of 1834 I was a boy on board the brig Calo, of Boston, a packet sailing between Boston and Baltimore, and commanded by Capt. Franklin Percival, of Barnstable, Cape Cod. We were on our passage from Boston to Baltimore and became becalmed near Cape Charles, Smith's Island being in sight. We had three or four fish-lines

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* Copy of extract entitled "Cape Cod turkeys for Virginia."

[Special dispatch to the Boston Journal.]

WASHINGTON, *February* 16.

The United States Fish Commission is endeavoring to propagate codfish in Chesapeake Bay. Some are caught by the fishermen on the coast of New Jersey, but it is very seldom that they have been caught inside of the capes. The codfish eggs are brought here for hatching, and the young fish will be sent to Fortress Monroe. Should the predictions of Professor Baird and his associates be realized, Chesapeake Bay will in a few years have fleets of codfishers rivaling the oyster fleet, and will supply the South and Southwest with fresh codfish.

on board, which were brought on deck and baited with clear salt pork (we having no other bait on board). The lines were lowered and immediately each line had a fish. On being hauled in we found them to be codfish, and for two hours we caught codfish as fast as we could lower and haul in our lines. We caught several hundred. A breeze sprang up, and we filled away for the Chesapeake. The weather being very warm, we dressed and split our fish and salted them in our chain cable boxes, having no other means to keep them. We arrived at Baltimore the next day, and there was a great demand for our corned codfish. We had a great rush for them and soon sold out. I have no doubt that codfish can be caught in the same locality to-day. It is but a short run from Norfolk, Va.

6 BOYLSTON HALL, BOSTON, MASS.,
February 20, 1882.

RECENT CONTRIBUTIONS TO POND CULTIVATION.*

BY MR. EBEN BANDITTEN.

Read at the general meeting of the Fishery Association of East and West Prussia.

[From *Deutsche Fischerei-Zeitung*, vol. 5, No. 6, Stettin, February 7, 1882.]

In all works on pond-cultivation, and by all practical carp-cultivators, spawning-ponds of small extent are considered best suited to the purpose.

With your permission I shall give a brief extract from the fourth report of the Fishery Association of East and West Prussia, for the years 1880–'81, which contains a general description of pond-cultivation:

"The spawning-pond, as its name indicates, serves for the increase of the carp. For this purpose small ponds of an area of one-tenth to one-half hectare are selected, with a depth of water remaining as much as possible the same at all times. Such ponds are easy to superintend; they are quickly warmed by the sun, and furnish ample food for the young fry. Only in a few places the water need be 1 meter deep, whilst its general depth should not exceed 10 to 20 centimeters. *Frogs are considered as dangerous enemies.* For spawning-carp well built and (especially as regards fins and scales) perfectly healthy fish are selected, weighing from 1½ to 2 kilograms."

The above was written by Prof. Dr. Benecke, the secretary of our association, who, by his enthusiasm for, his knowledge of, and his experience in, pisciculture, has gained an almost European reputation.

I fully subscribe to all he has said in the above quotation, but would remark at the same time that I, as well as many others, have not succeeded in raising carp with absolute certainty. The best proof of the

* "Neuere teichwirthschaftliche Mitheilungen."—Translated from the German by Herman Jacobson.

above will be found in the circumstance that innumerable inquiries on the subject, which, during this spring, I had addressed to many persons in Prussia, Silesia, Brandenburg, and Pomerania, were invariably answered negatively. This summer, however, I have made some interesting observations, showing that, also, with regard to this subject the well-known words of the greatest of our German poets are eminently true: "All theory, dear friend, is gray; but green the golden tree of life."

In my garden, which is close to my house, there is a meadow in a very favorable and sheltered position, which, in accordance with my principle, I had for some years used as a pond, and which was now again to serve for agricultural purposes. I have to go back to the preceding year. In the spring of 1880 I sowed suitable seed on the black pond-bottom, and as early as the middle of June, I was enabled to mow the finest grass at the rate of about one wagon-load per acre. The rainy season, which set in soon after June 24, lasted, with hardly any interruption, for seven weeks, and on the 14th August ended in a terrible flood, so that the beautiful meadow (10 acres in extent), which was almost ready for a second harvest of hay, was, within half an hour, flooded 5 feet deep, causing me again to use it as a pond. I intended to observe also, in pond-cultivation, the change of matter which, on a large scale, we had often had occasion to notice in agriculture. Formerly I had always used the pond as a spawning-pond for carp, but now I intended to use it as a pond for *raising* and *fattening* carp. As I knew the quantity of food contained in its waters, I this spring stocked the pond with about 500 carp, weighing on an average 1 to 1½ pounds each, 400 *Cyprinus orfus* of different size, and a few eels, and determined to raise ducks on this pond in the proportion of about 1 duck to each carp. I succeeded very well, 300 ducks, 100 geese, and 2 swans making this pond their residence for the summer. It should also be mentioned that a flock of young wild ducks, which had been caught in the neighborhood, were also quartered in this pond.

Although there was some danger that these aquatic birds might deprive the fish of much food, I fully expected that they, on the other hand, would furnish a great deal of other food for the carp. I found my expectations fully realized.

I must here remark that while, during the first months, the pond was swarming with immense numbers of frogs, both young and old, of which the older male frogs caused a good deal of trouble and danger to the old carp, these frogs were in a very short time entirely destroyed by the ducks. The croaking of the frogs which, as soon as warm weather set in, might be heard all night long, was heard no more. The more food the ducks received the more food also fell to the share of the fish.

I soon discovered that there were in the water of the pond large masses of spawn, both of the carp and of the *Cyprinus orfus*. I had supposed that the large number of aquatic birds (about 400), especially the ducks, would entirely devour the spawn. But this did not take place,

at least not to the extent that I had supposed. I had daily occasion to observe how the young fry flourished, although undoubtedly many young fish were devoured by the birds. The following was the result of my observations: Last autumn, about the beginning of October, I had about 50,000 very fine young carp, 100 of them weighing about 2½ pounds; of *Cyprinus orfus* I had only about 1,000. The weight of the old carp, originally weighing 1 to 1½ pounds, had increased 100 to 150 per cent.; while the weight of the *Cyprinus orfus* had not increased quite as much; and all this in the face of the fact that 300 ducks, 100 geese, and 2 swans, not to mention a flock of wild ducks (which are particularly fond of young fish), had staid on this pond all summer. Frog-spawn, which carp-cultivators, as a general rule, carefully remove from their ponds at the most suitable time, *i. e.*, in spring, I shall certainly put in this pond, where also during the coming year carp, *Cyprinus orfus*, ducks, and geese are going to live together in peaceful harmony. Frog-spawn forms a good, nourishing food for ducks, and consequently it will increase the quantity of carp-food. I considered the above observations, which are principally based on the change of matter (stoff-wechsel), of such importance as to deem it my duty to communicate them to my fellow-workers in the cause of pisciculture.

ON THE RACES OR VARIETIES OF CARP, DENYING THE EXISTENCE OF BLUE CARP AND GOLD CARP.

By F. ZENTZ.

[Translation.]

LOWER FRANCONIAN DISTRICT FISHERY ASSOCIATION, WÜRZBURG.

WÜRZBURG, *February* 13, 1882.

HONORED SIR: To-day, at last, I find time to answer your inquiry relative to *blue carp* and *gold carp*, and to return the enclosure of your letter.

RÉSUMÉ: There is no such fish as the *blue carp*, whether viewed from the standpoint of the naturalist or from that of the pisciculturist, and we will do all in our power not to increase, without any special object, the nomenclature of the carp, which has, as it is, too many names and subdivisions.

As it was my object not to report anything that is not authentic, I have reached the above result by conferring with several of the most experienced carp-traders and carp-raisers, and I have likewise examined a large number of different carp, some of them in tanks, all of which will sufficiently excuse my delay in answering your letter.

There are *three* principal races or varieties—not special kinds—of carp:

(1) The SCALE-CARP, *Cyprinus carpio* (French; *Carpe commune*), the

prototype of our wild carp, which even at the present day is the most numerous representative of our river carp. From the Main and the Rhine came to North Germany. It is frequently cultivated artificially in ponds.

(2) The MIRROR-CARP, the *carp-king*, *Cyprinus rex cyprinorum*, *Cyprinus speculum*, *Cyprinus macrolepidotus*, the most highly improved breed of carp of Central Germany, raised at the present time (the breed being kept pure) by the foremost pisciculturists of Franconia, the Upper Palatinate, and Bohemia. In its perfection it appears as a compactly built fish, with a thick body and a tendency to grow large, whilst the head remains small; very voracious, growing rapidly, but, like other carp, according to the varying circumstances, ready for spawning in the third year.

(3) THE LEATHER-CARP, *Cyprinus nudus*, *Cyprinus alepidotus* (French; "*carpe à cuir*"), entirely naked, a separate, well-determined race, and not, as Heckel and Kner think, a mirror-carp, whose scales have either not been properly developed, or which have fallen off from old age. Many of our pisciculturists make a specialty of raising mirror-carp with very few scales, and we therefore frequently find mirror-carp with only one row of scales, generally on the back.

At the present time, leather-carp of a beautiful golden brown color are greatly in demand in Germany; they are never called "*gold-carp*," but invariably "*leather-carp*."

Pisciculturists who do not follow the fashion, still prefer the thoroughbred *carp-king;* and it must be granted that a genuine mirror-carp is a model fish. When in the water its back has a bluish color, more or less with a greenish or gray hue, more decidedly bluish than the scale-carp or the leather-carp. The last-mentioned fish, when in the water, has only a very faint bluish color; the scale-carp is less blue than the carp-king, but under no circumstances can the blue color be considered as a mark of difference of race.

With regard to the gold-carp, I have already expressed an opinion when speaking of the leather-carp. Two years ago we had a large number of dead "*carpes d'or*" in our market, which came from the neighborhood of Saarburg, and as to growth and flesh, especially as to fine flavor, were far inferior to our Franconian carp. No more orders were given for this kind of fish, as, in spite of the moderate price, our people did not care for it. It is therefore not advisable to deteriorate our magnificent Central German carp races by the "*carpe d'or*."

According to all the descriptions—for I cannot here speak from personal knowledge—the *Cyprinus kollari*, *Cyprinus striatus* (French; "*carpe d'kollar*"), is a still more inferior fish. It is sometimes called the "*gold-carp*," or the "*gold bastard carp*"; is principally raised in the neighborhood of Paris and Metz, and also in Belgium, and is probably a cross between the bastard carp and the carp.

I therefore see no reason why I should advocate the name "*gold-*

carp," or why I should recommend this fish. Still less would I be inclined to do this if we are to understand by that name the *gold bastard carp*, or *chub* (?) *Caracino dorso crassior*, which, as I read, is found in ponds and rivers in Upper Saxony.

There are still more races of deteriorated carp:

Cyprinus elatus (French; "*carpe bossue*"), principally found in Italy.

C. regina (French; "*carpe reine*").

C. hungaricus (French; "*carpe de Hongrie*").

C. acuminatus.

None of these will be of any interest to pisciculturists.

I therefore say most emphatically: "Let people cease to seek after colored carp!" They are on the wrong road, and we ought not to be led astray in this respect by the evidently not well-informed Americans.*

We are therefore not able to give a history of the colored carp, especially as the history of the European carp is still shrouded in darkness. We know that its original home is Asia Minor and Persia, and that it was known to the Greeks and Romans, but it is impossible to say when it was first introduced into South and Central Germany and into France, and whether it was the Romans who, when entering those countries as conquerors, introduced it.

There is documentary evidence that it was cultivated in France as a pond fish as early as 1258, and about the same time in Germany. It was introduced into England in 1514, and into Denmark in 1660.

Possibly I may be fortunate enough to give you some further information relative to the carp in some future letter; at any rate, I shall be on the lookout for further information.

My best thanks for the second batch of *Salmo fontinalis*, which are flourishing. I intend to express my thanks in a more formal manner at some future time.

Respectfully, yours,

F. ZENTZ.

THE PECULIARITIES OF BLUE CARP.

BY HERR ECKARDT.

[Translation.]

The *blue carp* is distinguished from the other varieties of carp by its more compact build, its size, its blueish glittering color, when *in* the water, and its darker color when *out of* the water, its quiet temperament, and its greater capacity for taking and assimilating food. It does not become fit to spawn till its fifth year, and at that time weighs 7 to 12 pounds. Its home is South Germany, especially the neighborhood of Würzburg and Altenburg. It has been raised from Bohemian carp. I

* Note in some other handwriting: The *reverse* is the case!! We (without evil intention) led the Americans astray!!!

do not know anything more about it, except that it is highly prized by the Würzburg people. In spite of all the inquiries I have made, I have not been able to reach any certain result as to the *gold-carp*. I cannot get any from France, owing to the scarcity of spawn. I do not know whether there is anything mysterious about this fish, but, at any rate, I cannot learn any data concerning it. From Lohmann-Witten I have received what pretended to be "*carpes d'or*," but I do not know what fish these are which have been honored with this name; I believe they are common scale carp. I shall shortly reopen my correspondence with France, and perhaps I shall succeed. There are also *blue carp* of the *leather*, *mirror*, and *scale* varieties.

ECKARDT.

PLAN OF THE INTERNATIONAL FISHERIES EXHIBITION TO BE HELD AT EDINBURGH, SCOTLAND, AND A LIST OF PRIZES TO BE AWARDED.

BY J. A. LEONARD.

DEPARTMENT OF STATE,
Washington, March 7, 1882.

SIR: I have the honor to transmit herewith, for your information and consideration, a copy of a despatch from the consul of the United States at Leith, Scotland, in reference to the International Fisheries Exhibition, which is to be held at Edinburgh, Scotland, beginning on the 12th of April, 1882.

I am, sir, your obedient servant,

FREDK. T. FRELINGHUYSEN.

SPENCER F. BAIRD, Esq.,
Commissioner of Fish and Fisheries.

[Enclosure. Mr. Leonard to Mr. Davis, No. 21, dated January 26, 1882.]

PLAN OF THE INTERNATIONAL FISHERIES EXHIBITION TO BE HELD AT EDINBURGH, SCOTLAND, AND A LIST OF PRIZES TO BE AWARDED.

No. 21.] CONSULATE OF THE UNITED STATES,
Leith, Scotland, January 26, 1882.

SIR: I have the honor to submit herewith to your Department a report which I have compiled regarding the arrangements made for the International Fisheries Exhibition to be held in Edinburgh, Scotland, during April, 1882, such report including a statement of the objects of the exhibition, and lists of the prizes offered for exhibits and essays, and I trust that it will be found acceptable.

Dispatch No. 191, of date 15th July, 1881, from this Consulate to the Department of State, contained a notification that the exhibition above referred to would be held in Edinburgh, in the month of April, 1882;

and enclosed therein were two circulars which had been received regarding it.

I have the honor to be, sir, your most obedient servant,

J. A. LEONARD,
United States Consul.

Hon. J. C. BANCROFT DAVIS,
Assistant Secretary of State, Washington, D. C.

[Enclosure in No. 21.]

INTERNATIONAL FISHERIES EXHIBITION TO BE HELD AT EDINBURGH, SCOTLAND, APRIL 12, 1882.

Arrangements are now in progress for an International Fisheries Exhibition to be held at Edinburgh, Scotland, commencing on the 12th of April, 1882, and continuing open not less than two weeks.

The exhibition is promoted by the lord provost, magistrates, and town council of Edinburgh; the Highland and Agricultural Society of Scotland; the Merchant Company of Edinburgh, and the Scotch Fisheries Improvement Association. It will be presided over by H. R. H. Prince Alfred Ernest Albert, Duke of Edinburgh, K. G., K. T., K. P., and is under the patronage of more than a hundred of the nobility, officers, and distinguished citizens of Scotland, including the commissioners of Scotch Salmon Fisheries, Her Majesty's inspectors of Fisheries for England and Wales, the inspectors of Irish Fisheries, and the Fishmongers' Company of London. Archibald Young, esq., of Edinburgh, commissioner of Scotch Salmon Fisheries, is co-operating under the instructions of the secretary of state for the home department.

The exhibition is to include all kinds of articles connected with or illustrative of the fisheries of the world, and will be open to exhibitors from all countries.

The objects of exhibition and subjects for essays are exceedingly comprehensive, and are included in the following general classification:

I. Fish, aquatic birds, paintings, &c.

II. Boats and implements used in fisheries, &c.

III. Pisciculture, including models of apparatus, &c.

IV. Fish passes, including models.

V. Preserved fish, oils, specimens of salt for curing, &c.

VI. Tinned fish.

VII. Fish products, such as manures, isinglass, glues, models fish curing yards, &c.

VIII. Social condition of fishermen, models and drawings of harbors, houses, life-boats, food, clothing, systems of signalizing, light houses, fish markets, compasses, barometers, telescopes, &c.

IX. History of fishing, ancient implements, literature on the subject.

X. Pollution of rivers, systems and appliances for prevention, &c.

XI. Corals, aquatic fauna and flora, shell-fish, &c.

XII. Loan collections of any articles bearing on the above classes.

The following prizes are offered:

SPECIAL PRIZES FOR EXHIBIT.

1. Specimens of tinned fish of all kinds, £25.

2. Specimens of dried, salted, and smoked fish of all kinds, £50.

3. Models or plans of fishermen's dwellings, £10.

4. Models and drawings of fish passes and ladders, £20.

5. Model of the safest and handiest sailing fishing boat—hull, spars, sails, and rigging, £20.

6. Models and plans of piscicultural establishments, £10.

7. Models and plans of fish curing yards, £5.

8. Models and plans of apparatus for transporting live fish long distances in safety, £10.

9. Models and drawings of a handier and safer rig for the boats now in use on the east coast of Scotland than the lug sail, which requires to be dipped at every tack in beating to windward, £20.

10. Specimens or models and plans of trawl nets, £10.

11. Specimens or models and plans of bag, stake, and fly nets, £10.

12. Collections of inland fishing tackle, £20.

13. Fish-hatching apparatus, full size, with appliances and implements, £25.

14. Models or drawings illustrating the best system of rendering streams, polluted by sewage and manufacturing refuse, innocuous to fish life, £25.

15. Model of a fishing trawler, sail or steam, £20.

16. Eel trap for river not to interfere with other fisheries, £5.

17. Apparatus for catching crabs and lobsters, £5.

18. System of signalling at night for fishing fleets and vessels, £25.

19. Model of machine, worked by hand or steam power, for taking in trawl, cable, or herring nets, £15.

20. Improved salmon net, cotton or hemp, for use with cable, £5.

21. Improved herring net, £5.

22. Models of whale boats, and of all kinds of apparatus and tackle used in the seal and whale fisheries, £20.

SPECIAL PRIZES FOR ESSAYS.

1. On harbor accommodation for fishing boats on the east or north coasts of Scotland, pointing out the localities where harbors are most required, and distinguishing between natural coves or bays which may be converted into good harbors by artificial assistance, and places where the harbors must be entirely artificial, £25.

2. On the various methods of fish culture practiced in different countries of the world, £15.

3. On the various methods of oyster culture, £15.

4. On oyster culture in Scotland, including Orkney and Shetland, specifying the localities and the species and varieties of oysters most suitable, and discussing the effects of the laws at present in force, £20.

5. On the legislation at present applicable to the salmon fisheries in Scotland, and the best means of improving it, £10.

6. On the best means of increasing the supply of mussels for bait, indicating the most suitable localities for mussel beds, £20.

7. On the natural history of the herring, with special reference to its migrations, £10.

8. On the various means of curing and preserving fish at home and abroad, £15.

9. For the best description of the means used for curing and preserving the various kinds of fish caught on the coasts of Scotland, the Hebrides, and the Orkney and Shetland Islands, £15.

10. On the pollution of rivers, indicating especially the kinds of pollution injurious to fish life, £20.

11. On the salmon disease, £10.

12. On the migration of the Salmonidæ as affected by meteorological and other influences, £10.

13. Should there be a mesh fixed by law for herring nets, and, if so, of what size; or should fishermen be at liberty to use any size of mesh they please? £5.

14. On the best method of preserving fish alive for markets, £15.

15. On the artificial propagation of sea-fishes suitable for food, £10.

16. On the breeding and rearing of fresh-water fish, £10.

17. On the species of foreign fish most suitable for introduction into British rivers and waters, £15.

18. On the utilization of fish-offal, £10.

19. On the fish supply of great cities, with special reference to the best methods of packing and distribution, and other means calculated to facilitate the delivery of the fish in good condition for market, £20.

20. On the herring brand, £10.

21. On the food of fishes, both in fresh and salt water, accompanied by illustrations and preparations, £15.

22. On the natural history and habits of fresh-water trout, with special reference to the institution of an annual close time in Scotland, and the expediency of adopting a rod license, £10.

23. On the migration and spawning of sea-fish suitable for food, £10.

24. On angling associations, with code of rules for their management, £10.

25. On the relations existing between the annual migrations of sea-birds and the migrations of fishes, £10.

26. On the best modes of preserving ice, £10.

In addition to the above prizes, medals and diplomas granted by gov-

ernment for the encouragement of the exhibition will be awarded to deserving essayists and exhibitors.

It is announced that no application for space for exhibits can be received after the 1st of March, 1882, and that exhibits will be received from the 27th of March till the 4th of April.

It is also announced that all essays intended for competition must be lodged with the secretary on or before Monday, the 3d of April, 1882.

The place of exhibition, Waverly Market, is an iron and glass building, admirably adapted for the purpose, and furnishing a space of 6,810 square feet for exhibitors.

There is every reason to believe, from the applications already made for space in the exhibition, and from the interest shown by letters of inquiry, that, in addition to the exhibits of Scotland and other portions of Great Britain, there will be a large number of exhibits from Sweden, Norway, Russia, France, Germany, and other nations of Europe, and a number of entries have already been made from the United States.

The occasion will be a very favorable one for bringing the fishery products of our country, and its progress in fish-culture, to the attention of the people of Europe.

Full information, with copies of the regulations under which the exhibition is to take place, and entry forms, can be had from the secretary, Mr. Henry Cook, W. S., 3 George IV Bridge, Edinburgh.

J. A. LEONARD,
United States Consul.

FISHERY NOTES FROM GLOUCESTER, MASSACHUSETTS, CONCERNING COD, HADDOCK, HERRING, HALIBUT, AND MACKEREL.

By S. J. MARTIN.

Of the twenty-four boats that had nets, only five are left. They are doing very well. The fish they get are large and bring a high price. A fortnight ago the fish were all in one place, and that was small. The boats had their nets set across one another; the place was not over a quarter of a mile wide where they caught all the fish; now there are large fish all over the bay; they are doing better with nets than with trawls. The schooner Emma A. Osier came home last night to repair nets; had a crew of ten men; shared $46 to a man; can't pick that off every bush. The schooner Magellan Cloud landed 5,000 pounds of cod to-day, two nights' fishing. The schooner Morril Boys, landed 5,500 pounds, two nights' fishing; sold to-day for 3 cents a pound; good work. One of the boats is getting some new nets; the men think there will be good fishing all this month. The codfish on George's are larger this spring than they have been the last ten years; the fish are fatter this year than they have been for some time. There is a very large school of haddock on George's; the haddock are full of spawn.

All kinds of fish are high; dried George's codfish sold to-day for $6 a quintal; dried bank fish sold for $5.25 a quintal; fresh halibut, 11 cents a pound; fresh cod sold to-day for 3 cents a pound; fresh haddock, 2½ cents a pound; No. 1 mackerel, $20 a barrel; No. 2, $12 a barrel.

The cod gill-net fishing is done for this winter; only two boats are fishing with nets and they will finish this week. It is not because the nets do not fish well; the nets are worn out, and it is too late to get new ones.

The schooner Emma A. Osier was in Rockport yesterday; she had 228 codfish in number, which weighed 6,500 pounds, caught in three nights in nets; they were large fish; one of them weighed 98 and another 96 pounds. Trawls were set in the same locality with the nets. They cannot get such fish on trawls.

The George's vessels have done well since March 1; there have been 77 arrivals with split codfish. I think they will average 20,000 pounds to a vessel. If the fish were brought in round it would make a large sound. The fish bring a large price $3.25 a hundred, green out of the vessel. Dried George's cod are selling at $6 a quintal.

Plenty of frozen herring arrived during the last three days; twelve cargoes are in the harbor now. There are herring enough to last the fishermen till the middle of April. There are twelve more cargoes of frozen herrings to arrive yet; a large amount of it has been sold this winter.

The haddock fishing has been a great success. They are bringing in large trips from George's yet. The amount landed has been very large; four vessels stocked over $11,000, one has stocked $12,000—this has been done since the 1st of November. The amount brought from George's has been very large. I think I shall try and find out how many haddock have been caught there. I want to find out how many fish have been caught in nets this winter.

The halibut catchers have done poorly. The vessels now going will not pay their expenses. The schooner Bellerophon is given up as lost. Two of the best vessels that went after halibut are missing now. I hope that is all, but I fear not; I think some of them have had trouble with the ice, as there is plenty of it on the banks where they go after halibut.

Three mackerel vessels sailed for the south the 11th day of this month. That is the earliest that ever a vessel went south after mackerel. There will be ten vessels ready to sail next week. The three that sailed on the 11th were the schooner Edward Webster, schooner Ivanhoe, schooner Nellie Rowe. Good luck attend them.

GLOUCESTER, MASS., *March* 16, 1882.

PROGRESS AND RESULTS OF FISH CULTURE.

GERMAN CARP.

[From the Galveston Daily News, March 15, 1882.]

KOPPERL, *March* 14.—In December last, Mr. M. B. Hendricks, one of our most enterprising farmers, obtained from the fish commissioner a limited number of German carp. When brought here they were about one inch long. Now they are about six inches long and growing finely. Mr. Hendricks has expended a good deal of time and money in preparing for this experiment, and it bids fair to succeed. He has two large ponds and is building a third, all fed by springs on his farm. He has a fine supply of native fish, also.

RIXFORD, FLA., *March* 13, 1882.

DEAR SIR: I am pleased to be able to report that this morning, for the first time, my carp show signs of spawning. They come to the shore in pairs, and by threes and fours; show no signs of fear when I approach, evidently attending to business. Will report again as they hatch.

Very respectfully, yours,

GEO. C. RIXFORD.

Prof. S. F. BAIRD.

The fish above referred to were sent from Washington, November 6, 1879.

SUMMARY OF FISHING RECORDS, FOR SHAD AND ALEWIVES KEPT AT WILLOW BRANCH FISHERY, NORTH CAROLINA, FROM 1835 TO 1874.

By J. W. MILNER.

The following tables, prepared by the late Prof. J. W. Milner, chief assistant U. S. Fish Commission, are the first of a series designed by him to place on record all accessible data exhibiting the products and illustrating the fluctuations of our river fisheries.

Willow Branch Fishery, North Carolina, situated just within the mouth of the Chowan River, was one of the most valuable of the extensive seine fisheries lying around the head of the Albemarle. Its records, running almost continuously from 1835 to 1874, present most interesting material for study; and, when taken in connection with other records of the Albemarle fisheries which are extant, and cotemporaneous meteorological observations, will probably furnish valuable conclusions in regard to the laws or influences determining the great seasonal fluctuations in the river fisheries.

Summary of fishing records for shad and alewives, kept at Willow Branch Fishery, North Carolina, from 1835 to 1874.

Years and months.	Beginning of season.	Ending of season.	Number of days.	Total of shad.	Total of alewives.	Average per diem of shad.	Average per diem of alewives.	Date of maximum.	
								Shad.	Alewives.
1835	March 15	May 9	51	33,259	484,600	652	9,502	April 6–14.	April 13–19.
March			12	5,441	57,600	453	4,800		
April			30	26,645	344,500	888	11,483		
May			9	1,173	82,500	130	9,166		
1836	March 16	May 7	53	13,231	1,236,700	249	23,333	April 16–19.	April 17–26.
March			16	3,160	28,100	197	1,756		
April			30	9,619	939,600	320	31,320		
May			7	1,462	269,000	208	38,428		
1837	March 16	May 6	52	34,169	1,982,300	657	38,121	April 9–21.	April 23 and 24.
March			16	7,453	76,700	465	4,793		
April			30	24,566	1,635,600	818	54,520		
May			6	2,060	270,000	343	45,000		
1838	March 18	May 8	52	32,204	1,093,100	619	21,021	March 30–April 6.	April 17–19.
March			14	9,480	56,100	677	4,007		
April			30	19,739	785,000	657	26,166		
May			8	2,985	252,000	373	31,500		
1839	March 14	May 9	57	73,130	1,595,500	1,282	27,991	April 4–6.	April 26–May 2.
March			18	27,946	90,500	1,552	5,027		
April			30	43,351	1,205,000	1,445	40,166		
May			9	1,833	300,000	203	33,333		
1840	March 12	May 5	55	51,674	3,313,900	939	60,252	March 12–16.	April 16–23.
March			20	28,115	164,900	1,405	8,245		
April			30	22,736	2,985,000	757	99,500		
May			5	823	164,000	164	32,800		
1841	March 11	May 7	58	29,248	2,148,775	504	37,047	March 22–27.	April 16 and 23.
March			21	12,806	102,775	609	4,894		
April			30	16,014	1,665,000	533	55,500		
May			7	428	281,000	61	40,142		
1842	March 6	May 2	58	55,784	1,367,075	961	23,570	March 8–13.	April 21–24.
March			26	44,353	244,500	1,705	9,403		
April			30	11,373	1,105,575	379	36,852		
May			2	58	17,000	29	8,500		
1843	March 15	May 8	55	31,615	1,680,100	574	30,547	April 6–12.	April 21–28.
March			17	3,941	83,000	231	4,882		
April			30	25,894	1,293,100	863	43,103		
May			8	1,780	304,000	221	3,800		
1844	March 16	May 1	47	60,205	1,402,600	1,280	29,842	March 22–28.	April 16–22.
March			16	21,701	84,100	1,356	5,256		
April			30	38,414	1,314,500	1,280	43,816		
May			1	90	4,000	90	4,000		
1845	March 13	May 2	51	53,179	1,556,000	1,042	30,509	March 31–April 3.	April 16–20.

Summary of fishing records for shad and alewives, kept at Willow Branch Fishery, North Carolina, from 1835 to 1874—Continued.

Years and months.	Beginning of season.	Ending of season.	Number of days.	Total of shad.	Total of alewives.	Average per diem of shad.	Average per diem of alewives.	Date of maximum.	
								Shad.	Alewives.
1845.									
March			19	31, 832		1, 675			
April			30	21, 287	1, 527, 000	709	50, 900		
May			2	60	29, 000	30	14, 500		
1846	March 15	May 1	48	33, 117	718, 650	689	14, 971	April 3–6.	April 18–23.
March			17	10, 931	65, 350	643	3, 843		
April			30	22, 112	642, 300	737	21, 410		
May			1	74	11, 000	74	11, 000		
1847	March 15	April 29	45	21, 157	567, 140	470	12, 603	March 15–19.	April 13–18.
March			16	11, 722	100, 000	732	6, 250		
April			29	9, 435	467, 140	325	16, 109		
1848	March 14	May 5	53	16, 912	688, 460	319	12, 988	March 31, April 10.	April 28–May 24.
March			18	6, 821	40, 200	378	2, 233		
April			30	9, 732	540, 700	324	18, 023		
May			5	359	107, 500	71	21, 500		
1849	March 19	May 10	53	47, 017	389, 816	887	7, 355	March 24–April 3.	April 10–13.
March			13	16, 999	25, 676	1, 307	1, 975		
April			30	27, 933	314, 180	931	10, 472		
May			10	2, 085	49, 980	208	4, 998		
1850	March 12	May 7	57	25, 882	451, 103	454	7, 914	March 15–21.	April 27–May 3.
March			20	14, 417	15, 436	720	771		
April			30	11, 045	275, 967	368	9, 198		
May			7	420	159, 700	60	22, 814		
1851	March 11	May 2	53	12, 963	428, 650	244	8, 087	March 12.	April 28.
March			21	7, 664	18, 990	364	904		
April			30	5, 196	390, 160	173	13, 005		
May			2	103	19, 500	51	9, 750		
1852	March 8	May 14	68	34, 896	744, 428	513	10, 947	March 21–29.	April 6–24.
March			24	17, 877	59, 728	744	2, 488		
April			30	13, 820	454, 200	460	15, 140		
May			14	3, 199	230, 500	228	16, 460		
1853	March 7	May 6	61	37, 880	559, 800	620	9, 177	March 25–31.	April 25–27.
March			25	20, 416	53, 300	816	2, 132		
April			30	16, 273	434, 500	542	14, 483		
May			6	1, 191	72, 000	198	12, 000		
1854	March 9	May 10	63	28, 087	965, 500	445	15, 325	April 4–6.	April 22–May 2.
March			23	10, 996	34, 500	478	1, 500		
April			30	13, 370	664, 000	445	22, 133		
May			10	3, 721	267, 000	372	26, 700		
1855	March 12	May 11	61	32, 112	1, 105, 100	526	18, 116	March 28–April 20.	April 23–May 3.
March			20	10, 132	47, 200	506	2, 360		

April			20	18,300	592,900	610	19,763	
May			11	3,680	465,000	334	42,272	
1856	March 17	May 9	54	22,584	419,700	417	7,772	April 10–16.	April 21–28.
March			15	4,381	23,200	292	1,546	
April			30	16,669	303,500	555	10,116	
May			9	1,474	93,000	163	10,333	
1857	March 12	May 15	65	28,053	569,200	431	8,756	March 25–April 9.	Apri 28–May 2.
March			20	8,123	28,400	406	1,420	
April			30	17,007	338,800	566	11,293	
May			15	2,923	202,000	194	13,466	
1858	March 15	May 12	59	16,242	245,280	275	4,157	April 3–10.	April 15–24.
March			17	5,744	12,950	337	761	
April			30	9,238	206,200	307	6,873	
May			12	1,260	26,130	105	2,177	
1859	March 14	April 30	48	12,002	120,700	250	2,514	March 14–17.	April 11–27.
March			18	7,692	30,000	427	666	
April			30	4,310	96,700	143	3,223	
1860	March 12	May 12	63	17,125	144,100	271	2,287	March 22.	April 25–27.
March			21	8,809	20,700	419	985	
April			30	6,586	83,400	219	2,446	
May			12	1,730	40,000	144	3,333	
1861	March 11	May 16	67	21,101	915,450	314	13,663	April 2–6.	April 23–May 3.
March			21	7,782	85,200	370	4,057	
April			30	11,468	549,500	382	14,983	
May			16	1,851	280,750	115	17,546	
1862	April 7	May 12	36	38,286	567,583	1,063	15,766	April 7–11.	May 5–7.
April			24	34,534	301,135	1,438	12,547	
May			12	3,752	266,448	312	22,204	
1863	No record kept.	No record kept.							
1864	No record kept.	No record kept.							
1865	No record kept.	No record kept.							
1866	March 12	May 5	55	36,599	1,589,000	665	28,890	April 10–12.	April 20–28.
March			20	14,315	217,500	715	10,875	
April			30	21,605	1,019,500	720	33,983	
May			5	679	352,000	113	58,666	
1867	No record kept.	No record kept.							
1868	March 16	May 15	61	31,551	1,144,700	517	18,765	April 13–26.	April 23–May 5.
March			16	5,095	34,700	318	2,168	
April			30	21,774	674,000	725	22,466	
May			15	4,682	436,000	312	29,066	
1869	March 15	May 15	62	17,647	583,950	284	9,418	April 5–9.	April 21–27.
March			17	4,041	33,950	237	1,997	
April			30	11,612	426,600	387	14,220	
May			15	1,994	123,400	132	8,226	
1870	March 14	May 12	60	15,009	620,530	250	10,342	April 7–14.	April 14.
March			18	3,657	11,530	203	640	
April			30	9,739	421,000	324	14,633	
May			12	1,613	188,000	134	15,666	
1871	No record kept.	No record kept.							
1872	No record kept.	No record kept.							
1873	March 17	May 10	55	50,195	1,650,330	912	30,006	April 7–25.	April 28–May 3.
March			15	2,797	30,670	186	2,440		

Summary of fishing records for shad and alewives, kept at Willow Branch Fishery, North Carolina, from 1835 to 1874—Continued.

Years and months.	Beginning of season.	Ending of season.	Number of days.	Total of shad.	Total of alewives.	Average per diem of shad.	Average per diem of alewives.	Date of maximum.	
								Shad.	Alewives.
1873.									
April			30	41,501	976,360	1,383	32,545		
May			10	5,897	643,300	589	64,330		
1874	March 10	May 11	63	30,893	923,372	490	14,656	April 1–6.	April 22–May 5.
March			22	12,086	24,672	549	1,120		
April			30	17,049	572,300	568	19,076		
May			11	1,758	326,400	159	29,672		

AN INQUIRY AS TO THE CAPTURE OF YOUNG CODFISH IN CHESAPEAKE BAY.

BY J. W. COLLINS.

WASHINGTON, *March* 23, 1882.

Prof. S. F. BAIRD,
Commissioner of Fisheries, Washington, D. C.:

DEAR SIR: I herewith submit a copy of a letter and replies to questions concerning the capture of young codfish in Chesapeake Bay, which I have just received from Mr. P. W. Savage, of Cherrystone, Va.

Respectfully,

J. W. COLLINS.

CHERRYSTONE, VA., 3, 21, 1882.

DEAR SIR: I have, according to promise, seen the party who caught the fish that I was talking to you about while at this place, and have answered your interrogations.

Any information or assistance I can give will be gladly given.

Very respectfully,

P. W. SAVAGE.

Capt. J. W. COLLINS,
Washington, D. C.

LIST OF QUESTIONS AND REPLIES.

1. Date of capture?—Answer. Some time in June.

2. What kind of apparatus were the fish caught in?—Answer. Haul seines.

3. Length of fish?—Answer. Six to eight inches.

4. The exact locality where they were taken?—Answer. At the mouth of Hunger's Creek.

5. Number of fish caught?—Answer. Some six or eight; don't know exactly.

6. Were they all taken at one time or at various dates?—Answer. Thinks they were caught three or four times.

7. Is there any doubt of these fish being the true cod?—Answer. Some said they were [cod]; others said there was a doubt. Some fishermen took them for "pollit" or "pollock."

[It is very desirable to prove the existence of cod in Chesapeake Bay by the possession of specimens caught there, and it is hoped that persons who capture what they believe to be that fish will forward some of them to the United States Commissioner of Fisheries at Washington. Young cod were introduced in the bay by the United States Fish Commission last winter, and it is thought that some of these have been taken by fishermen. It is proper to remark here that two species of hake are

known to occur in the bay, one of them very abundantly; but as these have only two fins on the back while the cod has three, it will be easy to distinguish them; young pollock, too, can be at once distinguished from cod by the long lower jaw, which protrudes far beyond the upper, even when the mouth is closed.—EDITOR.]

ON THE INSENSIBILITY OF THE GERMAN CARP TO FREEZING.

BY DR. GEORGE WIGG.

[Extract from a letter to Prof. Spencer F. Baird.]

I have a German carp in my office frozen stiff six times in one month, yet each time after six hours came out all right; am going to put him into a tub in the garden.

CLAY CENTER, MO., *March* 23, 1882.

FIRST ARRIVAL OF MACKEREL IN NEW YORK IN THE SPRING OF 1882.

BY CAPT. J. W. COLLINS.

[Letter to Prof. Spencer F. Baird.]

Mr. W. A. Wilcox, writing from Boston, under date of April 1, says: "The first new mackerel arrived in New York this afternoon. Schooner Nettie Rowe—new vessel from Gloucester—brings in fifty barrels; all large fine fish."

AN INQUIRY INTO THE FIRST FOOD OF YOUNG LAKE WHITEFISH (*Coregonus clupeiformis*)

BY PROF. S. A. FORBES.

[A letter to Prof. Spencer F. Baird.]

I write only to inform you of the successful conclusions of a final experiment relating to the first food of the lake whitefish. I kept several thousand in a tank in the Exposition Building in Chicago, and kept them constantly supplied, for two weeks, with everything that a towing-net of very fine Swiss would take from the water of the lake. A hundred specimens were put into alcohol every two days, and finally all remaining were similarly preserved. During the latter part of the time they could be easily seen pursuing and catching the entomostraca. I have not time at present to examine the fishes preserved, as I am busy with other work. I have just searched the intestines of ten, taken out March 23, to get at some idea of the result of the experiment. Taking them at

random, opening the intestines under the microscope, and preserving the contents either as microscope slides or in capillary vials, I found that these ten specimens had eaten twenty-four entomostraca, all belonging to two species, descriptions of which I have in press, viz: *Cyclops thomasi* and *Diaptomus sicilis*—fourteen of the first and ten of the second.

Besides these I found only a few diatoms (*baccillaria*) in two of the fishes; a little fragment of a filament of an alga in one, and three rotifers (*Anuræa striata*) in another.

I will prepare a full account of the experiment, with a description of the developmental conditions of the fishes when they commenced to eat, and a full analysis of their food, as soon as I have time to do the work.

I am indebted to Mr. Clark for the specimens; to the Chicago Exposition Company for the use of the tank, and to the State of Illinois for the expenses of the experiment.

ILLINOIS STATE LABORATORY OF NATURAL HISTORY,
Normal, Ill., March 27, 1882.

NOTES ON THE BREEDING, FOOD, AND GREEN COLOR OF THE OYSTER.

By JOHN A. RYDER.

No mollusk known to the naturalists, it appears, is consumed in such vast quantities as our native oyster, the *Ostrea virginica* of Gmelin; hence its great economic importance and the scientific interest which it has recently awakened. It is vastly superior in flavor, size, and vigor of growth to the oyster of Europe, and is simulated and approached only by one old Continental form which I have seen, probably the *Ostrea rostralis* of Lamarck. The first attempt made in the artificial impregnation of the eggs of this noble mollusk was successful in the hands of our countryman, Prof. W. K. Brooks, of Johns Hopkins University, of Baltimore, who, in 1880, published a remarkable memoir on the subject in the annual report of Maj. T. B. Ferguson, one of the fish commissioners of Maryland. Professor Brooks' triumph was not, however, as complete as might have been desired, since his investigations have not yet led to the development of methods whereby the oyster could be propagated by purely artificial means, but his success was so far beyond what was attained by Dr. Davaine in his attempts at the artificial fertilization of the European oyster in 1851, that Brooks' achievement marks the most important era in the history of the subject. Others, as well as the writer, have repeated his experiments with more or less success, and the latter has been able to work out a portion of the developmental history of *Mya arenaria*, clam or mananose, using artificially impregnated eggs for the purpose, which were dealt with the same as those of the oyster.

An earnest, and, it is to be hoped, successful effort is being made by

the United States and Maryland Fish Commissions to introduce the most approved French methods into the waters of Maryland and to supplement these by even more advanced methods, if practicable. The results of the observations and experiments of the writer during the last two years have been embodied in part in a report to the Maryland commissioner for the year 1881, which has been favorably received. Additional papers have been contributed for the same report for 1882, and to the bulletin of the United States Fish Commission, bearing mainly upon the anatomy, finer structure, and development of the animal. An imperfect list of the published works on the subject has also been compiled by the writer; a more complete catalogue of the literature of the subject in all languages will shortly be published by the Dutch Government.

What has already been put upon record it will not be worth while to discuss, and we will therefore recapitulate only where necessary, adding sundry new facts not yet recorded. To our knowledge of the early development of the animal we have added nothing. The account given by Brooks for the American, by Salensky, Gerbe, Fischer, and Davaine for the European, species, with little qualification, remains the same. The detachment of the ring or crown of vibratory filaments or cilia from the embryo oyster as asserted by Davaine has not been confirmed by any other observer. Hatschek has lately contributed some valuable researches in regard to the development of young bivalves. Working, however, upon the embryo ship-worm, his studies have no direct bearing upon the oyster, but they nevertheless throw considerable light upon the mode of development of the gills, upper gill cavities, liver, muscles, foot and nervous system of the great group to which both belong. This last research shows that the conversion of a part of the velum or ciliary crown above the mouth into palps and gills, as held by Lankester, does probably not take place. The occurrence of ciliary bands running from the edge of the mantle on its inner side to the mouth, as observed by the writer in spat one-eight of an inch in diameter, was supposed at first to confirm Lankester's view, but Hatschek's researches have made such an opinion untenable. The physiological function of the bands was, however, clear; by the vibration of the filaments composing them they establish currents towards the mouth, which hurl the food of the young spat into its spacious throat, serving in part the same purpose as the velum adjoining the mouth of the fry.

Brooks has represented the freshly laid ova of the oyster with a spherical nucleus and nucleolus; the former is large, clear, and spherical, and is embedded near the center of the egg; the nucleolus is situated inside of the nucleus in a somewhat eccentric position. I do not find the latter spherical, but formed as if composed of a larger and smaller highly refringent pair of spheres partly fused with each other, or of the same form as the nucleoli of the eggs of *Anodonta*, as described by Flemming, and somewhat similar to those of the slipper limpet (*Crepi-*

dula glauca), as observed by the writer. Some very singular figures of the eggs of the European oyster in Poli's *Testacea sicilitæ*, published in 1795, renders it not improbable that he may have seen this singularly formed nucleolus.

The ova are not all "ripe" in all cases at the same time in the same ovarian tubules. The same condition of affairs is found in the ovary of the oyster as was observed in that of *Scrobicularia* by Von Jhering; that is, while some ova were mature others in the same tubule or follicle were still very immature. The condition of the ovary varies, however, considerably in different individuals; in some cases the most of the ova are ripe at about the same time, in others there is a greater difference between the time of maturity of different eggs. It is also frequently observed that a portion of the generative organs of the same oyster are much more advanced in maturity than other portions. The ovaries and spermaries are never entirely wasted away or atrophied, as would appear to the naked eye. The full, enlarged appearance which is noticed when the generative glands are full of ripe products is often due to a distension of the ducts which lead away from the tubules or follicles, and when this is the case, if the handle of a scalpel is gently stroked over the distended ducts over the side of the animal, from its head end towards the posterior portion below the muscle, the ova or spermatozoa, as the case may be, can be forced out of the open end of the main efferent generative duct into the upper gill chamber of its own side, into which the former opens, as described in the anatomical outline sketch given in my report to the Maryland commissioner for 1881, page 15.

It has recently been asserted by some Dutch investigators that the generative products were not discharged by way of a single duct on either side of the animal, as described by Lacaze-Duthiers. What anatomical grounds these observers have for this statement I do not know; they appear to have been investigating the structure of the animal by means of thin slices or sections. The simple experiment with a sexually ripe oyster, as described above, has invariably given the same result; never more than a single opening was found on one side from which the eggs were seen to issue. So far thin sections of the oyster as observed by me have not shaken my belief in the accuracy of the observations of Lacaze-Duthiers, nor have I seen any evidence of three generative openings and ducts on either side of the European oyster, as asserted by Davaine, nor is it worth while to more than notice Home's error with regard to the water-chamber above the gills, which he regarded as the oviduct.

At the time the oyster is full of spawn, the generative organ completely envelops the viscera (liver, intestine, and stomach) except a small portion at the anal end of the intestine, and the head end of the visceral mass. All of the deeper tubules or follicles composing the generative gland trend towards, and join directly or indirectly the main duct on either side of the body, into which they pour their products as the latter

are received from the canalicular structures in which they are matured. At no time do we find the generative organs quite undeveloped. If they are not apparent to the eye in winter, sections show the ducts and microscopic rudiments of germinal follicles or tubules, as a net-work of strands of minute germinal cells, which traverse in all directions the coarse superficial layer of vesicular connective tissue cells, miscalled the "fat." As the breeding season approaches, the minute germinal cells of this net-work of rudimentary reproductive cells commence to grow until they attain the development observed in the animal when full of spawn. The ducts or follicles are never developed in the mantle, but the substance of the latter may come into contact externally and superficially with the generative organs.

The terms "fry" and "spat" I have endeavored to use in such a way as to avoid confusion. As soon as the egg has developed far enough to move about by means of the fine motile filaments with which it is partially covered, it may be considered to have reached the fry stage of development, and to have *hatched*, but it is to be borne in mind that an oyster egg does not hatch in the same sense as does the egg of a chick or fish, that is, by breaking its egg shell or membrane, because the oyster egg is without a membrane such as must be cast off in the act of hatching in the former cases. As soon as it has ceased to rove about in the water, and has fastened itself to some other object, it has attained the stage of development known to oystermen by the term "spat."

Our researches (see Maryland Report, 1881) show that the dimensions of the fry of the American oyster at the time it ceases to be "fry," fixes itself, and becomes spat, is about one-eightieth of an inch, and at that time the valves are characterized by a very remarkable symmetry, which is departed from as soon as the growth of the shell begins in its new fixed position. The manner in which this attachment is made has not been learned, but it is very probable that this is accomplished by means of a larval byssus. Such a conclusion appears to be warranted by the fact that the larvæ or swimming young of most of the allies of the oyster are provided with a byssus or threads for their temporary anchorage, such as may be seen very strongly developed in the adult salt-water mussel.

All theorization in regard to the nature of the mechanism of fixation aside, however, it now becomes a question of the most profound importance for us to endeavor by experiment to maintain artificially impregnated oyster eggs alive for a long enough time after they begin to swim, so that they may have an opportunity to attach themselves. The experiments of those who have hitherto worked upon the development of the oyster have shown us that this is exceedingly difficult to do, and that beyond the present stage of our knowledge and experience much still remains to be achieved. Various forms of apparatus have been tried with indifferent success. The experiment of using bibulous paper diaphragms through which the sea-water was allowed to pass was a failure; the pores

of the paper soon became clogged with fine sediment, so as to stop the flow of water. Bolting-cloth does not have the meshes fine enough to hold the eggs; besides, it is expensive and not durable. The use of a membrane of filtering paper, with nickel-plated wire cloth above and below the paper in order to strengthen it, and forming the bottom of hatching-boxes placed inside of another and larger box from which the sea-water was allowed to escape rapidly through an intermittently active siphon, and constantly run in very slowly, was found to clog, as in apparatus where the flow was only in one direction. Although the contrivance was automatic, as the outer box filled up, the inflow into the inner box with the porous bottom containing the eggs was interfered with both by the swelling of the fibers of the paper as well as by the accumulation of slimy sediment in the substance of the latter. The outflow from the inner boxes through their porous bottoms was then impeded from the same causes, and as the siphon emptied the outer box the water in the inner boxes would not fall quickly enough to effect any considerable change. Filtering the water did not seem to help matters sufficiently to make it an object to filter a supply for the purpose. Here our experiments have broken down completely, and all the results so far reached with such apparatus have not been of sufficient value to make it desirable to repeat them in the same way, though they have been conducted with three different forms of apparatus.

Recently Prof. S. I. Smith, of Yale College, has succeeded in incubating the eggs of certain crustaceans in shallow plates without changing the water at all, but by simply aerating and keeping it in constant circulation by means of jets of air playing constantly upon its surface. This mode of hatching appears to fulfill the requirements of the case fully, as far as I can now see, and it will be of the greatest importance to test this method at the earliest possible opportunity. By its use we will be enabled to avoid the loss of eggs which would follow from the use of any method in which there is a current of water constantly running in and flowing out of the incubating contrivance.

Should we be able to artificially incubate the eggs of the oyster and keep them alive until the time when the embryos attach themselves to foreign objects, we will have attained such a success as will probably never be paralleled in any other branch of fish culture. The artificial impregnation of the eggs of the oyster may be accomplished to the extent of thousands of millions; and, should it be found possible to keep their hosts of young alive until they had passed certain critical periods of their embryonic existence, we would have practically succeeded in adding so many millions of spat to those already existing, from which seed might be supplied for the foundation of extensive beds where oysters had been previously unknown.

Brooks, in carrying his embryos along for the period of six days, encountered the same difficulties as myself. If, as I have good evidence for premising, when the young oyster ceases its wandering habit its

valves measure one-eightieth of an inch in their longest diameter, we have yet to find out how old it is when of this size. When we learn this we will know how long it will be necessary for us to keep the young in the incubating apparatus. We can reach the answers to these questions only by the use of the proper sort of hatching arrangement, in which artificially impregnated eggs are used, being careful, of course, to keep accurate records of the time of impregnation and the fluctuations of temperature of the air and water during the progress of the experiment. With the finer questions of the anatomy of the embryos we will have little to do; in fact, I do not see that they will help us much in the comprehension of how the hatching process is to be conducted, which goes without denying, however, that the experienced embryologist must be expected to determine whether the development is progressing properly. When once the development has been carried to the stage of fixation the embryologists will have an abundance of opportunity to make out the finer details of structure, and let us remark in regard to the oyster, one of the most accessible of animals, that much still remains to be done by both the anatomist and embryologist.

Whatever may be the form of the apparatus which will finally be used in artificial oyster culture, it will also be necessary to provide some sort of cheap and effective method of providing for the attachment of the young fry to some substance or object which may be transferred to *nurseries*, where the spat is to undergo further development. This *cultch*, or collecting apparatus, must be suitable for immersion in the shallow incubating vessels among the developing fry. Clean pebbles, graded through a sieve of the proper mesh, at once suggest themselves as admirably fitted for the purpose, but what is most suitable will have to be learned by experiment. To facilitate the study of the spat immediately after fixation, slips of glass and mica, arranged so as to depend into the water in the hatching apparatus, would probably provide the microscopist with very young fixed stages, which could be transferred to the stage of the microscope without disturbing their attachments, the nature of which could then be readily ascertained on such transparent cultch.

The special merit of the proposed method of artificial culture from the egg upwards would be that we could probably do without the cumbrous tiles, slates, &c., covered with mortar, such as are used abroad. In fact, if *collectors* are to be used at all after the French mode, it would seem to the writer that it would be just as well to use old oyster shells and the cheapest possible materials strewn over arable bottoms near productive spawning oyster beds, as is pretty extensively practiced on the coast of New England, especially Connecticut, and, to some extent, in places on the Chesapeake Bay. If any considerable advance is to be made in the culture of the oyster, it will be by a radical departure from a class of methods which have been in use for over ten centuries. The old method is founded on well-ascertained natural principles, and there is no reason why more modern discoveries should not greatly increase

the effectiveness and radically change the manner of the propagation of this most valuable of all food shell-fish. Besides, the great cumbrousness of tiles, &c., involves a great outlay of labor, such as would be a serious item in their practical utilization in the United States, where labor is much more expensive than in continental countries. Not only is this objection valid, but a still more serious one is the uncertainty of the set of spat, which catches on any sort of natural or artificial cultch. In some seasons the collectors will be overcrowded, in others no spat will be found to adhere. The same element of risk is encountered in the use of old oyster shells as cultch for the spat, and, as I have been told by oystermen of large experience, several thousands of dollars' worth of shells may be strewn upon good oyster bottom, upon which not a single spat will be found at the end of the season, thus involving a loss of both material and labor. I do not see that any method in which tiles or mortar-covered slates are used will be a particle more likely to afford a nidus for spat than old shells or the cheapest kind of cultch, except in some places where the latter is liable to be covered with mud or sediment.

This uncertainty, it appears to the writer, can be overcome by a totally different method of procedure. We must have the temperature of the water and conditions of the artificially fertilized and confined embryos under control. The uncertainty which has hitherto attended oyster propagation must disappear measurably in the face of intelligent experiment, and it is to be hoped that in a few years we will hear of oyster nurseries or incubating establishments in successful operation, from which millions of spat will be annually bred from artificially impregnated eggs to be sold as seed to planters, who will enter upon the business of oyster cultivation on an entirely new and scientific basis. Whether all that we have pictured can be realized may be a matter of doubt with many, but at any rate it is a stage of the oyster industry which, if possible of attainment, ought at once and vigorously to be striven for under the auspices of both public and private enterprise. Unlike the propagation of many kinds of fishes, the results of oyster culture can be watched from the earliest fixed stages onwards and progress noted; they do not, like fishes, move about from place to place, but after fixation may be kept under observation in the same situation until they have reached a marketable size. This is a most satisfactory feature of the work, and ought to attract observers.

Of no less moment than the introduction of radically new and more certain methods of propagation is the question, upon what materials does the oyster feed? How does its different kinds of food affect its flavor and appearance? What are the conditions which will most quickly bring it into a plump, marketable condition? The most contradictory and confusing statements are made by different persons in regard to the feeding habits of the animal, and anomalous as some of them may at

first appear, many of them doubtless have some foundation in substantial fact.

Professor Leidy, before the Academy of Natural Sciences of Philadelphia, has recently stated it as his belief that oysters probably feed on the zoöspores of certain algæ, such as those of *Ulva latissima* (sea cabbage), which he knew from personal observation to be green, and which he thought might possibly be the cause of the green coloration of the soft parts of the animal frequently observed in both the American and European species, and which, I am convinced from observation, originates from the same source in both species. Very possibly the spores of *Ulva* may be the cause, but, judging from what I have seen and heard from oystermen, as well as from what I have read in various publications relating to this matter, I am not inclined to regard this as the only source of the green observed in the oyster. Without being able to state positively what it is, we may take it for granted that the color is of vegetable origin, and therefore quite harmless. That it is not copper we may be equally certain, for any such quantity of a copper salt as would produce the green gills and patches on the mantle, such as are often observed, would without doubt be as fatally poisonous to the oyster as to a human being. The source of the green has recently been investigated by two French savants, MM. Puysegur and Decaisne, who found that when perfectly white-fleshed oysters were supplied with water containing an abundance of a green microscopic plant, the *Navicula ostrearia* of Kützing, their flesh acquired a corresponding green tint. These investigators also found that if the oysters which they had caused to become impregnated with this vegetable color were placed in sea-water deprived of the microscopic green vegetable food, the characteristic color would also disappear. Whether this will finally be found to be the true explanation remains to be seen, as some recent investigations indicate that it is possible that a green coloration of animal organisms may be due to one of three other causes besides the one described above as the source of the green color of the oyster. Patrick Geddes, in a recent number of *Nature*, has pointed out that "the list of supposed chlorophyl containing animals * * * breaks up into three categories: first, those which do not contain chlorophyl at all, but green pigments of unknown function (*Bonellia*, *Idotea*, &c.); secondly, those vegetating by their own intrinsic chlorophyl (*Convoluta*, *Spongilla*, *Hydra*); thirdly, those vegetating by proxy, if one may so speak, rearing copious algæ in their own tissues, and profiting in every way by the vital activities of these." The last is one of the most interesting and important of modern biological discoveries, that living animal bodies may actually afford a nidus for the propagation of green microscopic plants, and not be injured but rather be benefited thereby. The oxygen thrown off by the parasitic vegetable life appears to be absorbed by the tissues of the animal, while the carbonic dioxide gas thrown off by the latter is absorbed by the vegetable parasite, thus affording each other

mutual help in the processes of nutrition and excretion. This singular association and interdependence of the animal host and the vegetable guest has received the somewhat cumbrous name of *Symbiosis*, which may be translated pretty nearly by the phrase associated existence. This is not the place for the discussion of the purely scientific aspect of this question, as already ably dealt with by Dr. Brandt, Patrick Geddes, Geza Entz, and others, and we will therefore only notice their researches in so far as they appear to have a bearing upon the origin of the green color of the oyster. Entz has discovered that he could cause colorless infusoria to become green by feeding them with green palmellaceous cells, which, moreover, did not die after the death of their hosts, but contined to live growing and developing within the latter until their total evolution proved them to be forms of very simple microscopic green algæ, such as *Palmella*, *Glœocystis*, &c. (E. P. Wright). My own observations on some green microscopical animals have been of so interesting a character, that I will here describe what I observed in a green bell-animalcule. Next the cuticle or skin in the outer layer of their bodies, in all stages, a single stratum of green copuscles were found to be uniformly embedded, like the chlorophyl grains observed as a superficial layer in the cells of some plants—as in *Anacharis*, for example. The same arrangement of the green corpuscles had been observed in *Stentor*, the trumpet-animalcule, many years before, by Stein. There may be parasites, as observed by Dr. Entz, but, judging from their superficial position, their globular form, and behavior towards reagents, the absence of a nucleus or of any cleavage stages, they must, it seems to me, be regarded as integral parts of the creatures in which they are found.

A grass-green planarian, *Convoluta schultzii*, found at Roscoff by Mr. Geddes, was discovered by him to evolve large amounts of oxygen like a plant, and "both chemical and histological observations showed the abundant presence of starch in the green cells, and thus these planarians, and presumably, also, *Hydra*, *Spongilla*, &c., were proved to be truly vegetating animals." Similar facts have since been observed in relation to other green animals by the same naturalist.

That the green observed in a number of animal organisms is of the nature of chlorophyl, or leaf green, has been proved by Lankester (see Sach's Text-book of Botany, p. 687), by means of the spectroscope. A. W. Bennett, in alluding to Lankester's observations, says: "In all cases the chlorophyloid substance agrees in having a strong absorption band in the red—a little to the right or left; and except in *Idotea*, in being soluble in alcohol, and in having strong red fluorescence, and in finally losing its color some time after its solution.

The vegetable organisms which have been found to inhabit the lower forms of life alluded to above have been regarded as belonging to two genera by Dr. Brandt, which he has named *Zoöchlorella* and *Zoöxanthella*, and which are probably synonymous with the genus *Philozoön* proposed by Mr. Geddes. But the latter claims to have demonstrated the

truth of the view that the yellow cells of radiolarians and polypes are algæ; secondly, the foundation of the hypothesis of the lichenoid nature of the alliance between algæ and animal into a theory of mutual dependence; and, thirdly, the transference of that view from the region of probable speculation into that of experimental science.

Hitherto no one has, apparently, noticed the occurrence of green vegetable parasites in bivalve mollusks except Professor Leidy, who has kindly permitted me to use the facts observed by him relating to *Anodon*, one of our common fresh-water mussels. In this animal he observed what he regards as algous parasites, living within the cells of the tissues of the molluscan host, larger than nuclei of the cells of the latter, and lodged in clusters in their paraplasm. These facts, observed a long time since, render it very probable that Professor Leidy was one of the first, if not the first, to notice the intracellular parasitism of a plant in an animal.

Amongst some oysters which were obtained from England through the kind offices of Messrs. Shaffer and Blackford, in response to a request coming from Professor Baird, certain ones were found which were decidedly green. Of these the French specimens of *Ostrea edulis* and a singular form labeled "Anglo-Portuguese" had the gills of a greenish hue, and in some of the latter the liver, heart, and mantle was very deeply tinged in certain parts, so much so that I decided to make as critical an examination as my resources could command at the time. Spectroscopic investigations gave only negative results, as it was found impossible to discern any positive evidence of chlorophyl from the spectrum of light passed through thin preparations of some of the green-tinted portions of oysters, some of which, like those made from the heart, were decidedly green to the naked eye. There was no absorption noticed at the red and blue ends of the spectrum, such as is observed when the light which enters the slit of the spectroscope first passes through an alcoholic solution of leaf-green or chlorophyl. Indeed, the spectrum did not appear to be sensibly affected by the substance which causes the coloration of the oyster. No attempt was made to still further test the matter with the use of alcoholic green solutions obtained from affected oysters, as the former were not obtainable with a sufficient depth of color because of the relatively small amount of coloring matter present in the animals. If any of the coloring matter was derived from diatoms the spectrum of phycoxanthine was also not developed. Unstained preparations of the natural green hue were used in all of these experiments. Some unstained balsam preparations of the green portions, especially of the heart, showed that the color, which was at first localized and confined to the green cells, after a while became diffused so as to give the preparation a uniform greenish tinge. This is proof of its soluble and consequently diffusible nature.

Finally, in order to see if the color was due to the presence of copper, Prof. H. C. Lewis, of the Academy of Natural Sciences of Philadelphia,

kindly made some delicate tests for me, using small dried fragments of an oyster very deeply tinged with green in various regions, especially in the liver, connective tissue, and mantle. The fragments were burned in a bead of microcosmic salt and chloride of sodium on a clean platinum wire in a gas flame. This test did not give the characteristic sky-blue flame which should have been developed had there been the minutest trace of copper present. This portion of the research I since find was superfluous, as Professor Endlich, of the Smithsonian Institution, in 1879, had already gone over the same ground chemically, making every test he could think of to learn whether there was any metallic or other poisonous substance present in some green oysters which had been submitted to him by the health officers of Washington, who supposed that they might contain something unhealthful, and should therefore be excluded from the market. Professor Endlich, however, found nothing that he considered hurtful.

Sachs, in his Text-book of Botany, p. 222, says: "The diatoms are the only algæ, except the Conjugatæ, in which the chlorophyl occurs in the form of discs and bands, but in some forms it is also found in grains, and the green coloring matter is concealed, like the chlorophyl grains in Fucaceæ, by a buff-colored substance, diatomine or phycoxanthine."

It appears, then, according to the foregoing quotation, that it is not impossible for diatoms to be the cause of the green color in oysters, and that the objections urged by some against them as a cause of it is founded on a misapprehension of their structure. I find that the liver is normally of a brownish-red color in both the American and European oysters, but that it often has a decidedly greenish cast in green ones, and that this is due not to a parasitic animal or plant, but to a tinction or stain which has affected the internal ends of the cells which line the follicles or ultimate saccules of the liver. This color is able to survive prolonged immersion in chromic acid and alcohol, and does not allow carmine to replace it in sections which have been stained with that color, the effect of which is to produce a result similar to double staining in green and red. The singular green elements scattered through the connective tissue remain equally well defined, and do not take the carmine dye. I at first believed the green cells to be parasitic. I also supposed that starch granules were apparent, but physical tests failed definitively to reveal them. The large and small green granular bodies in the connective tissue and those close to the intestinal wall I find present in white-fleshed oysters, but simply with this difference, that they are devoid of the green color. It is therefore evident from this simple fact that they cannot be of the nature of parasites, though the color is primarily limited to them only. This condition observed by me in various specimens of American and European oysters does not, however, disprove the possibility of the occurrence of vegetable parasites in these animals.

In some very "poor" Falmouth oysters very much affected with green coloration the gills, heart, and mantle were most notably colored. Some

of them were tinged with an unusual depth of color, so much so that to one unacquainted with the cause they would doubless have been repulsive, and unlikely to have stimulated any gustatory feelings. In one of these I found a large cyst or sack near the edge of the mantle, and forming a cavity in its substance one-half inch in length by one-fourth in width. The hearts of the affected specimens were found to have their walls apparently thicker than those of unaffected ones, the muscular trabeculæ which interlaced on the inside were found to have entrapped and held in their meshes vast numbers of the loose, green cells precisely like those which freely escaped from the cyst alluded to above. These green cells were quite as independent of each other as the ordinary discoidal corpuscles in the serum of the red blood of a vertebrate. The green cells were sometimes confined to the anterior or the posterior wall of the ventricle, sometimes to its upper or its lower end, sometimes the entire ventricle was so loaded with them as to render it quite opaque when viewed with transmitted light. These cells under high powers were invariably found to have about the same appearance; were of about the same size, with a distinct nucleus placed eccentrically; frequently with evidence of pseudopodal prolongations extending laterally from the sides. The nucleus could be very nicely demonstrated with iodine or acetic acid as a refringent, globular body one six-thousandth of an inch in diameter. The dimensions of the cells would average about one two-thousandth of an inch, or one-fourth of the size of the connective tissue cells. Now for their identification, which was accomplished as follows: An application of the well-known crucial test for starch gave a negative result. When iodine was first applied to the cells in strong solution, and afterwards treated with sulphuric acid, with the result that the characteristic blue reaction was not developed, showed that there was no cellulose wall covering them, and that they were not parasitic algous vegetable organisms. In potassic hydrate they underwent complete solution, a further proof of the absence of cellulose and their non-vegetable character. Their dimensions, one two-thousandth of an inch, is about that of the blood-cell of the oyster. The nucleus is in the same position as in the blood-cell of the animal. Their usual occurrence in the gills and frequent presence in the heart, caught in the meshes of the muscular trabeculæ of its wall, is almost positive proof of their true origin and character. Furthermore, I find in sections that they sometimes occlude the blood-channels, or are adherent to their walls. In the cyst in the mantle, as in the heart, they are free, and in the normal untinged heart they are not abundant. All of the foregoing facts indicate that these green bodies are in reality blood-cells which belong to the animal. How they became green is not easy to determine without a careful examination of some of the localities where such green oysters are plentiful. The fact that I found instances in green oysters where a greenish material was found in the follicles of the liver, the lining cells of which were also affected, would

indicate that the color was probably absorbed from the food of the animal, which, as we know, consists largely of vegetable matter. The green coloration of the liver, I am convinced, is not due in such instances to a hepatic secretion, which, by the way, is not normally of this color in the oyster. It is not improbable that the blood-cells imbibing the color from the tinged nutritive juices transuded through the walls of the alimentary canal acquired the color of the food which has been dissolved by the digestive fluids. How to account for the accumulation of the green cells in the heart and in cysts in the mantle is also a difficult question, unless one be permitted to suppose that the acquisition of the green color by the blood-cells is in reality a more or less decidedly diseased condition, for which we again have no ground in fact, since the green oysters are apparently in as good health as the white ones. They are found "fat" or "poor," just as it may have happened that their food was abundant or the reverse.

If it be objected that the green color indicates an unhealthful condition of the animal, it may be stated that still other color variations of the flesh have fallen under my observation recently. What I allude to now is the yellowish, verging towards a reddish cast, which is sometimes noticed in the gills and mantle. This, in all probability, like the green color, is due to the reddish-brown matter which is contained in much of the diatomaceous food of the animal. Mr. J. M. Carley has also called my attention to these variations, and was inclined to attribute it to the soil in the vicinity of the beds. But if the classical writers are to be trusted, to the green, yellow, and white fleshed sorts, we must add red, tawny, and black fleshed ones. Pliny tells us of red oysters in Spain, of others of a tawny hue in Illyricum, and of black ones at Circeii, the latter being, he says, black both in meat and shell. Horace and other writers awarded these black oysters the palm of excellence (O'Shaughnessy). However, the black appearance may have been due to an abundance of the natural purple pigment in the mantles of the animal, which varies very much in different species; some, judging from the dark purple color of the whole inside of the shell, must have the whole of the mantle of the same tint. The amount of color in the mantle, especially at its border, varies in local varieties of both the American and European species, as may often be observed.

As to the culinary value of green oysters my own experience has indicated that as far as their taste is concerned they are not perceptibly inferior to the white-fleshed ones. While in New York recently I was enabled, through the kindness of Mr. J. M. Carley, to test the comparative eating qualities of the two sorts pretty satisfactorily. When stewed, no difference was perceptible to the taste, and not the slightest suspicion of an acrid metallic flavor could be detected, such as would have undoubtedly been perceptible had copper been present in poisonous quantities. Professor Leidy about the same time tried a similar experiment with the same result, concluding that the difference in

quality between the white and green fleshed sorts was imperceptible to the taste. In conversation with a restaurateur quite recently, the latter volunteered the information that he was in the habit of selecting the green-fleshed oysters for his own eating, declaring that they were perceptibly superior, in his estimation, to the white ones. This is the only instance that has come to my knowledge where the preference was given to the green oyster, as appears to be the case in England and on the Continent.

Without having made any special effort to collect data regarding the occurrence of green oysters on the coast of the United States, I may say that they are probably quite as common here as in Europe, and that the cause is the same; at any rate it is certain that many more "greened" oysters are consumed in the restaurants of eastern cities than is generally supposed. During the last three years I have found that they occur almost everywhere along the eastern coast. Amongst the localities may be mentioned, Lynn Haven Bay, York and Hongres Rivers, Virginia. I have been told that they occur along the Atlantic coast of Maryland and Virginia, as at Chincoteague Island, for example. I am informed by Mr. Carley that they also occur in New York Bay and Long Island Sound; in fact I have seen some from those localities. A Philadelphia dealer also tells me that they occur on the coast of New Jersey, both in the vicinity of New York and along the southern portion. I have met with them in a number of instances in saloons where it was impossible to trace them to the beds whence they came. In every case they presented the same appearance as those which I have seen from abroad. The European oysters which have fallen under my observation, and which were most affected, were the French, Falmouth, and Portuguese sorts.

The most important glandular appendage of the alimentary tract of the oyster is the liver. It communicates, by means of a number of wide ducts, with somewhat plicated walls, with a very irregularly formed cavity, which we may designate as the stomach proper, in which the food of the animal comes into contact with the digestive juices poured out by the ultimate follicles of the liver, to undergo solution preparatory to its absorption during its passage through the singularly-formed intestine. If thin slices of the animal are examined under the microscope, we find the walls of the stomach continuous with the walls of the great ducts of the liver. These great ducts divide and subdivide until they break up into a great number of blind ovoidal sacs with longitudinally folded parietes, into which the biliary secretion is poured from the cells of their walls. A thick stratum of these follicles surrounds the stomach except at its back. It is not quite correct to speak of the liver of the oyster as we speak of the liver of a higher warm-blooded animal. Its function in the oyster is the same as that of three different glands in us, viz, the gastric follicles, the pancreas, and liver, to which we may possibly add the salivary, making a total of four in the higher animals which are

represented by a single organ in the oyster. In fact experiment has shown that the secretion of the liver of mollusks combines characters of at least two if not three of the glandular appendages of the intestine of vertebrated animals. There are absolutely no triturating organs in the oyster for the comminution of the food; it is simply macerated in the glandular secretion of the liver and swept along through the intestine by the combined vibratory action of innumerable fine filaments with which the walls of the stomach, hepatic ducts, and intestine are clothed. In this way the nutritive matters of the food are acted on in two ways: first, a peculiar organic ferment derived from the liver reduces it to a condition in which it may be absorbed; secondly, in order that the latter process may be favored it is propelled through an intestinal canal, which is peculiarly constructed so as to present as large an amount of absorbent surface as possible. This is accomplished by a double induplication or fold which extends for the whole length of the intestine, the cavity of which, in consequence, appears almost crescent-shaped when cut across. On the concave side, the intestinal wall on its inner face is thrown into numerous very narrow, longitudinal, and interrupted folds, which further increase the absorbing surface. Such minor folds are also noticed in the stomach, and some of these may even have a special glandular function. There are no muscles in the walls of the intestine as in vertebrates, but the sole motive force which propels the indigestible as well as digestible portions of the food through the alimentary canal is exerted by the innumerable vibratory cilia with which its inner face is clothed.

This apparatus is admirably suited to render the microscopic life found in the vicinity of the animal available as a food supply. The vortices created by the innumerable vibratory filaments which cover the mantle, gills, and palps of the oyster, hurl the microscopic edible hosts down the capacious throat of the animal, to undergo conversion into its substance, as described above. The mode in which the tissues may become tinged by the consumption of green spores, diatoms or desmids, it is easy to infer from the foregoing description of the digestive apparatus of the animal. The colorless blood cells, moving in a thin *liquor sanguinis*, would, judging from their amœbiform character, readily absorb any tinge acquired by the latter from the intestinal juices. The color in them is, however, homogeneously distributed through the substance of the green cells, and is not due to the presence of any organisms or particles within them. No bacteria or putrefactive organisms were ever observed by me in oysters except in such as were spoiled or putrid.

I have discussed in another place, in a desultory way, the microscopic marine fauna of the Chesapeake Bay, where I have been engaged upon the study of the oyster under the auspices of the United States and Maryland Fish Commissions, but what I have done has been simply preliminary, and necessarily incomplete. Before we are ready to deal with the matter on which the oyster feeds, we desire a more perfect acquaint-

ance with the microscopic life which grows upon the oyster beds and swims about in the adjacent waters. From the fact that the lower forms of life in fresh water often appear in great abundance one year, while in the next, from some unexplained cause, none of the same species will be found in the same situation, we may conclude that similar seasonal variations occur in the facies of the microscopic life of a given oyster bed and its vicinity. Such yearly variations in the abundance of microscopic life are probably the causes of the variable condition of the oysters taken from the same beds during the same season of different years. Violent or sudden changes of temperature are probably often the cause of the destruction of a great amount of the minute life upon which the oyster feeds. Backward and stormy seasons probably also affect the abundance of the microscopic life of the sea. All of these questions have, however, as yet, been scarcely touched, and, judging from the disposition of many of our students of zoology to be content merely with a description of new species and the compilation of lists, instead of also entering into the life-histories, relative abundance of individuals, and the influence of surrounding conditions upon the forms they study, it will take some time yet before we get the information so much desired. When we arrive at this knowledge we will know why it is that oysters taken from a certain bed are in good condition for a season or two, and then for one or more years are found to be watery and of poor quality, as well as why it is that the oysters of certain beds, which for years have had a high reputation for their fine qualities, are suddenly found to be more or less green in the beard, as I have been informed is now the case with the oysters of Lynn Haven Bay, Virginia.

Speaking of the abundance of the *Navicula ostrearius* Kützing, Mr. Benjamin Gaillon, in 1820, said that they inhabit the water of the tanks or "parks" in which the oysters are grown in France in such immense abundance at certain periods of the year that they can only be compared to the grains of dust which rise in clouds and obscure the air in dusty weather. Dr. Johnston, speaking of the French oysters, says that, "in order to communicate to them a green color, which, as with us [in England], enhances their value in the market and in the estimation of the epicure, they are placed for a time in tanks or 'parks,' formed in particular places near high-water mark, and into which the sea can be admitted at pleasure by means of sluices; the water, being kept shallow and left at rest, is favorable to the growth of the green *Conferva* and *Ulva*, and with these there are generated at the same time innumerable crustaceous animalcules, which serve the oysters for food and tincture their flesh with the desirable hue." Without stopping to criticise the statement regarding the crustaceous food of the oyster, the foregoing extract gives us some hints regarding the advantages arising from the cultivation of oysters in more or less stagnant water, in which, as in the French parks or claires, an abundance of microscopic life would be generated in consequence of a nearly uniform temperature, higher in the early autumn months at least than that of the water of the open

sea, where cold currents also would tend to make it still less uniform, and thus interfere with the generation of the minute food of the oyster. In other words, it would appear that the effect of the French method is to furnish the best conditions for the rapid and constant propagation of an immense amount of microscopic food well adapted to nourish the oyster; that, unlike oysters exposed to a rapid flow of water on a bottom barren of minute life, they grow and quickly attain a saleable condition.

In this country narrow coves and inlets with comparatively shallow water appear to furnish the best conditions for the nutrition and growth of oysters, and according to my own meager experience these are the places where we actually find the minute animal and vegetable life in the greatest abundance; and, as might have been expected, the oysters planted in such situations appear to be in good condition early in the autumn, long before those which are found in deeper, colder, and more active water, where their microscopic food has less chance to multiply.

As to the influence of brackish water in improving the condition of oysters, let me observe here that those who hold to that opinion appear to forget to bear in mind the fact that brackish water beds are often in the case just described. Being in shallow, relatively quiet water, an abundance of food is generated, which is rapidly consumed by the animals, which quickly brings the latter into condition, the brackish state of the water getting the credit of the result.

In my report to Maj. T. B. Ferguson, I stated my belief in the practicability of establishing permanent oyster banks or ridges. During the last summer, in the Cherrystone River, Virginia, I saw my idea practically realized. A heap of shells in the river had been scattered so as to form a low, solid elevation, which was alternately covered and uncovered by the rise and fall of the tide. Upon this spat had caught in such multitudes and grown, until the whole in two years was as completely and solidly covered by living, natural-growth oysters as any natural bank I had ever seen. The desirability of using the poorly-grown stock from natural and artificial banks as "seed" for planting appears reasonable, and could no doubt be made profitable where banks of sufficient extent could be established from which a supply of seed oysters could be obtained.

SMITHSONIAN INSTITUTION,
Washington, April 15, 1882.

NOTES ON THE FISHERIES OF GLOUCESTER, MASSACHUSETTS.

By S. J. MARTIN.

[Letters to Prof. S. F. Baird.]

The cod net fishing is done for the year. The amount of codfish caught in nets during this winter was 640,000 pounds. If the codfish had been plentiful the catch would have been very large.

There have been 25 boats fishing with nets. The average was 20 nets to a boat. Some of them stopped fishing with nets the first of March.

The majority of the haddock-catchers have stopped fishing for this year. Five of the largest, however, will continue fishing for haddock during the summer. The haddock-catchers have all done well this winter.

I will tell you some of the stocks. Schooner Mystic stocked $17,576.44; schooner Reporter stocked $15,300; schooner Martha C. stocked $12,600. These are the three largest. The average stock of the fleet is $9,000. The price for haddock has been high all winter. Some of the vessels have been offered $1.80 per hundred until the 1st of June, for all they could catch. They refused that price. They think they will do better.

The George's fleet has done very well. The price for salt fish is high, $3 a hundred pounds out of the vessels. All the fish the vessels have brought in this spring have been split. No round ones as in former years. The halibut catchers have fetched in some good trips recently. They have made large stocks. The price for halibut, as well as for all kinds of fresh fish, has been good. Halibut sold yesterday at 7 cents per pound; cod, 3 cents per pound; haddock 2 cents per pound. These are high prices for this time of year.

They are catching some herring in the harbor; that will start the small boats.

I am sorry to say there are two more vessels missing—two of the George's fleet. They have been gone six weeks. The owners have given them up. The mackerel fishing looks well for the year to come. No old mackerel in the market. All kinds of fishing look well for this year.

GLOUCESTER, MASS., *April* 9, 1882.

I send the amount of fish taken at Gloucester during the month of April:

George's cod (salt fish)	pounds	2,114,000
George's halibut	do	38,000
Western bank codfish	do	2,128,000
Western bank halibut	do	30,800
Grand bank halibut	do	407,000
Haddock (caught on George's)	do	205,000
Haddock (shore)	do	183,800
Cod (shore)	do	107,100
Imported fish (dried haddock)	quintals	197
Imported fish (dried hake)	do	96
Herring (frozen)	number	200,000
Herring (fresh) caught at Gloucester and sold to the fishermen	barrels	275

GLOUCESTER, MASS., *May* 3, 1882.

THE CAPTURE OF SHAD AT ISLES OF SHOALS, NEW HAMPSHIRE.

BY CEDRIC LAIGHTON.

I have just arrived home, and the first thing I have done was to make inquiries in regard to the shad. Haley, our head boatman, assures me that it is a fact that the shad were taken here last August. He informs me that Josiah Randall took them in his seine off Lounging Island to the number of 10 barrels the latter part of last August. Jim Haley also informs me that Samuel Robinson, in the schooner Can't Come It, some years ago off York Beach, in August, took over 90 barrels of shad in his seine.

APPLEDORE HOUSE,
Isles of Shoals, Portsmouth, N. H., April 3, 1882.

THE INTRODUCTION OF LAND-LOCKED SALMON INTO WOODHULL LAKE, NEW YORK, AND THE SUBSEQUENT CAPTURE OF SOME OF THEM.

BY SETH GREEN.

[Letter to Prof. S. F. Baird.]

Two years ago I sent 9,000 land-locked salmon to Bisby Lake, in the north woods. When they got to Woodhull Lake it was dark; the carry from there was over a rough road, and the cans had to be carried on the men's backs the rest of the journey. They built a fire and camped on the shore of the lake. The weather was very warm and their ice was gone; the water got so warm that the fish began to suffer and they saw they were going to lose them. They rowed them out in the middle of the lake and put them in the lake. I did not expect to hear from them again, as they were, many of them, in bad condition, and I did not think the lake a very favorable one for that kind of fish.

Last week there was a guide here from the Bisby Lakes to get young fish; he said they were taking a good many land-locked salmon in the Woodhull Lake. One man caught five in one day. They are 18 inches long, and weigh one and one-half pounds each. I saw one of them, and it was a fine and well-fed fish. This is the first we have heard of the land-locked salmon that we have planted. But now I am sure we will hear from more of them. There may be plenty of them in the waters that we have put them in, and no one has fished for them that knew how to take them. I expect to try some of the waters this season, and have no doubt will take them and teach the people how, and give a good report.

NEW YORK STATE FISHERY COMMISSION,
Office of the Superintendent, Rochester, April 22, 1882.

ADDITIONAL OBSERVATIONS ON THE RETARDATION OF THE DEVELOPMENT OF THE OVA OF THE SHAD.

BY JOHN A. RYDER.

The following data supplement and confirm in a somewhat remarkable manner the arguments put forth by the writer in an article on the retardation of the development of the eggs of the shad, published in this Bulletin, pp. 177–190, 1881. The facts there recorded were the results of experiments carried out with the help of apparatus specially designed to artificially lower the temperature of either the air or water in which the eggs were hatched. The value of the present series of observations depends entirely upon the fact that no artificial means were resorted to for the purpose of lowering the temperature, but that the eggs experi, mented upon, obtained, as they were, as early as the 9th day of April were, in consequence of the then prevailing low temperature of the water, subjected to no extraordinary or artificial condition arising from the use of a complex water-or air-cooling apparatus. The temperature of the water of the Potomac during the progress of the incubation of the eggs in question was at times as low as 48° Fahr., but as a rule the water then in use in the McDonald hatching jars, the apparatus utilized in the experiment, fluctuated only between 50° and 56° Fahr., and even then very gradually, as the variation during any one period of twelve hours was rarely more than 1° Fahr. There was a gradual but very slight rise in the temperature of the water from the beginning to the end of the experiment, which covered seventeen days. This gradual rise was covered by six or seven degrees Fahrenheit, as already stated. The average temperature of the water for the whole period was 53¾° Fahr., which, as we see, was only a little above the "danger point," 52° Fahr., if we may so call it, as indicated by my observations made in association with Messrs. McDonald and Clark last year. The results of this experiment have shown us that it is possible to retard the development of shad ova so as to prolong the period of incubation for a period five times that normally occupied in the process in the height of the spawning season, or for almost fifteen days. During my somewhat extended observations on the eggs of this species, no such length of time of incubation has been recorded, nor has any one, to the best of my knowledge, recorded the fact that under such conditions of temperature the progress of the evolution of the embryo was perfectly normal, as was the case in the instance now to be described. Several persons have insisted that shad ova developing in too low a temperature would be found to be imperfect, especially the eyes, which, it was said, did not apparently develop at all. The lowest temperature in which I have seen shad ova develop normally was 49°.5 Fahr., as recorded in my report of the experiments during the spring of 1881. Neither in those nor in the

embryos which are the subject of this paper was any abnormality observed in the development of the eyes or optic vesicles.

Now for the history of the progress of the experiment and the ova. The latter were taken at one of the Potomac stations organized upon the plan proposed by Colonel McDonald. They were impregnated on the 9th of April at 7 p. m., and brought to the Armory on trays and spread out on damp cloths by spawn-taker Jones. They were placed in one of the McDonald jars on the morning of the 10th of April, but, unfortunately for the fullest fruition of our hopes, during the night, owing to an accidental occurrence or to the meddlesomeness of some irresponsible busy-body, too large a supply of water was turned on, causing the largest proportion of the eggs to be thrown out by way of the escape pipe of the jar. What were then left, amounting to probably two or three thousand, had to suffice for the material for this account of their development.

On the 11th of April, the temperature of the water was 57° Fahr. It had been about the same or a little lower on the 9th and 10th; the water of the Potomac, from which they were obtained at Ferry Landing, was on those dates as low as 48° Fahr. On the 12th, the thermometer indicated a temperature in the hatching apparatus ranging from 50° to 51°.5 Fahr. On the 13th, the temperature ranged from 51° to 52° Fahr. This was the fourth day, and sketches taken from the eggs at this time showed that the blastoderm was just about to close, a condition ordinarily attained in a temperature of 74° Fahr., in somewhat less than 24 hours. On the 14th of April, the temperature was 52° to 53° Fahr.; on the 15th, 53° Fahr.; on this, the sixth day, the tail began to bud out. On the 16th, the temperature was the same as on the previous day, and the tail had, by this time, the seventh day, grown to about one-third the length of that of the just-hatched embryo. On the 17th, the temperature was 53°.5 Fahr.; on the 18th, 51°.5 to 52° Fahr.; on the 19th, 53° to 53°.5 Fahr.; development still normal. On the 20th, the temperature ranged from 53° to 54°; on the 21st, 55° to 55°.5 Fahr., and about this time, or on the twelfth day, the eyes began to show the first signs of pigmentation, becoming a shade darker than hitherto, verging toward brown. On the 22d, the temperature of the water was 56°, falling to 55°.5 Fahr.; on this, the thirteenth day, a few began to hatch; the eyes were now fully pigmented and normal in their development. On the 23d, the temperature of the water was 55° 5 to 54° Fahr. On the 24th, the temperature was from 54° to 54°.5 Fahr. During the 23d and 24th days of April, the hatching continued, most of the embryos having ruptured their inclosing membranes on the 24th of April, or the fifteenth day of incubation. On the 25th, the temperature ranged between 54°.5 to 55° Fahr., and on this date, or the sixteenth day, a few of the ova still remained unhatched. On the 26th, the temperature was 55° Fahr., all of the ova were now hatched, and no abnormalities of any sort were noticed. The embryos, however, were for

the most part lost, owing, as I think, to the circumstance that the water was allowed to flow too rapidly and violently through the hatching jar.

The behavior of the hatching jar was most admirable, but would have been still better had there been a larger quantity of eggs put into the apparatus. The most meritorious feature of the apparatus is the almost entire non-development of the saprolegnious fungus, which causes so great a mortality in some other forms of hatching contrivances in which all of the ova are not in continual movement. The very gradual, gentle, and continual rolling movement of the ova upon each other in the jar apparently prevents the spores of the fungus from adhering. The cleanliness of the apparatus is also to be commended, whereby the use of skim nets for cleaning is dispensed with, while the material of which it is made—glass—enables one to watch the progress of development very satisfactorily from the outside of the jar with a hand-glass or pocket lens of moderate power.

On the seventeenth day of the experiment the hatched embryos were in the condition of those normally developed at 70° to 75° Fahr., the yelk being ovoidal, clear, and plump. At the rate at which the development progressed, it would take five times as long to absorb the bulk of the yelk of an embryo at a temperature of 53°.75 Fahr. as at 75° Fahr., or about 25 days. This period, added to the prolonged time of incubation at 53°.75 Fahr., would cover a space of forty days, or more than twice the time required to carry embryo shad to the farthest confines of Europe. The probability therefore is, that we have exceeded the lowest temperature practically required for this purpose; 55° Fahr. being a much more favorable and less dangerous temperature than that prevailing during the successful experiment of which we have just given a detailed account.

WASHINGTON, *April* 26, 1882.

GROWTH AND SPAWNING OF GERMAN CARP IN ALABAMA.

By A. G. BARNES.

[Letter to Prof. S. F. Baird.]

It will perhaps interest you to have a report from my German carp. Those received January 12, 1881, are now 20 inches in length. The first indications noticed of their breeding were in March last (the nineteenth day). A lot of eggs, found attached to the grass, was taken and place in a tub, and the young were seen on the seventh day afterwards—the weather cool and wet. Again, on 2d instant I saw them depositing their eggs. A lot of these eggs placed in a tub hatched out on the fourth day—the weather warm and pleasant—the water during the day indicating about 70°. Those hatched 26th March are now 1¼ inches in length.

Your prediction that they would spawn in the South in their second year proved true. My carp have made more rapid growth, and have propagated a year sooner than in their native waters. I have not tested their eating qualities, but as my pond is now well stocked I propose to try one or two of my breeders, as soon as they recuperate from the exhaustion necessary to spawning. My success, so far, has been eminently satisfactory, and now when I find, by test, that I have, in addition to this other good quality, a good *food* fish, I shall be more than compensated for my trouble, expense, and waiting. With my experience, I do not hesitate to say the Southern waters are peculiarly well adapted to the propagation and raising of carp.

GAINESVILLE, ALA., *April* 21, 1882.

NOTES ON THE FISHERIES OF GLOUCESTER, MASSACHUSETTS.

By S. J. MARTIN.

[No. 1.—Letter to Prof. S. F. Baird.]

The George's vessels have not done much the last week. They have to go to Grand Manan after bait; that makes the trips longer. Three halibut fares have been landed this week; small fares. Halibut bring a high price, selling during the past week at 9 cents a pound for white and 6 cents a pound for gray. The outlook for fresh fish is good. Haddock have not been sold for less than 2½ cents a pound. Cod have been sold for 3 cents per pound all the week. There is a good school of cod in Ipswich Bay—large fish. Schooner Rising Star caught 20,000 pounds in three days. The rest of the boats did as well. One of the Rockport boats set 12 nets, where they were getting 6,000 pounds on trawls in one day. When they hauled the nets they took 200 pounds. They cannot get trawl fish in nets, or net fish on trawls. That has been well tried. The Southern mackerel fleet have not done much. The schooner Mertie Delmar was in New York Monday; she had 130 barrels of medium-sized mackerel caught thirty miles southeast from Cape Henry. Last year the first mackerel were caught on the 23d day of March. The next, April 19, when 12 sail arrived with 1,705 barrels. The next were caught April 25, when 30 sail arrived in New York with 6,000 barrels of fresh mackerel. The mackerel sold in New York Tuesday at 12 and 10 cents each. All the old mackerel are out of the market. The first salt mackerel will bring a good price. I hope the mackerel-catchers learned a lesson last summer about selling their mackerel out of pickle to save inspection. They began to sell mackerel out of pickle five years ago. The last three summers it has been carried on extensively. Mackerel sold out of pickle last year for $4 per barrel were sold afterwards for $10 per barrel. I do not see where the general inspector gets his pay when the mackerel are sold out of pickle; that

is, if he gets so much for inspection on a barrel. Perhaps the law is altered; if not, there is a great deal of hush money. When mackerel are sold out of pickle it hurts the market. When the speculator gets them they are all culled over; number one's made of number two's and number two's made of number three's; and they make twelve twenty-pound kits out of a barrel. If a man buys inspected mackerel, he gets what belongs to him. If they are not inspected, he does not; so much for that.

The boat that arrived from Ipswich Bay this morning was the Annie Hodgdon, with 15,000 pounds of nice cod, from two days' fishing with trawls. A school of haddock have been on the coast the past three days. One man in a dory yesterday caught 500 pounds half a mile southeast from Eastern Point. If there is plenty of bait the small vessels will do well. Prospects good for all kinds of fish.

GLOUCESTER, MASS., *April* 16, 1882.

[No. 2.—Letter to Prof. S. F. Baird.]

I thought I would write a few lines about the last week's fishing in Gloucester. There have been twelve vessels from Western Bank with 780,000 pounds salt fish; 30 vessels from George's, averaging 15,000 pounds to a vessel; ten vessels with 210,000 pounds haddock; two vessels with 50,000 pounds of fresh halibut. The haddock have all been sold to the splitters. There is no market for haddock and cod. There are plenty of mackerel and shad in New York. There have been fifteen vessels in New York with 1,600 barrels of mackerel. Shad are sent on from New York in large quantities to Boston market. That hurts the sale of cod and haddock. There has been a good school of large cod in Ipswich Bay. The shore boats do well when they have plenty of bait. Herring are more plentiful than they have been. Herring are half grown. The men in the harbor with nets sell all they can get at 50 cents a bucket. Haddock are more plentiful this year in the month of April than they have been for eight years. On a fine day the dories get from three to four hundred pounds half a mile from the Point. There were three Lynn boats here yesterday; they had 20,000 pounds of haddock to a boat, caught on middle bank in two days' fishing. That has not been done during the past five years. The first salt mackerel were sold in New York for $8 a barrel. Fish of all kinds are a shade lower. Dried George's cod sold at 5½ cents a pound. Fresh halibut have sold all the week at 11 cents a pound. Fresh cod 1¾ cents a pound. Fresh haddock 1 cent a pound. Mackerel sold in New York, Saturday, at 4 cents a piece. Shad sold in Boston, Saturday, at 10 cents a piece. Whales are plentiful out in the bay, sometimes coming close to the shore; a number have been shot over at Provincetown. The George's vessels report plenty of herring on George's.

GLOUCESTER, MASS., *April* 23, 1882.

[No. 3.—Letter to Prof. S. F. Baird.]

There have been thirty arrivals from George's with light fares, averaging 12,000 pounds to a vessel; twelve sail from western bank with good fares, averaging 60,000 to a vessel; six sail from the banks with fresh halibut, averaging 30,000 pounds to a vessel; 120,000 pounds of haddock have been landed this week. Haddock remain plenty in-shore. The vessels carrying their fish fresh to market do not go farther than middle bank. They get 10,000, 12,000, and 15,000 a day. The dories, with one man, go one mile from the mouth of the harbor and bring home from 400 to 600 pounds at 2 p. m. This has not been done for the last ten years. In the month of May there is a small school of haddock comes in-shore and stays about a week. This has been the case for the last four years. The herring are more plentiful in-shore than they have been during the past fifteen years—I mean spring herring. Eighty barrels were in a trap at Kettle Island on Friday night and 60 barrels last night. Schooner Phantom came in this morning with 60 barrels caught with a seine four miles from the mouth of the harbor. The herring caught outside are large—as large as the spawn-herring caught in the fall; those caught in the harbor are half-size. They sell as fast as they are received. The western bankers take 40 barrels. No bait to be had on the Nova Scotia shore. The vessels carry their bait from Gloucester. Herring sold this morning $2 per barrel. All kinds of fish come nearer the shore this spring. Mackerel are close to the shore. They have been caught eight miles from the Delaware breakwater. The price of fish, with the exception of mackerel, rule the same as last week. Salt mackerel were sold Friday in Philadelphia for $6 per barrel. The first sold for $8 per barrel.

GLOUCESTER, MASS., *April* 30, 1882.

GROWTH OF THE SÄLBLING (SALMO SALVELINUS) IN THE OLD COLONY TROUT PONDS AT PLYMOUTH, MASSACHUSETTS.

By W. L. GILBERT.

[Letter to Prof. S. F. Baird.]

I have some 400 *Salmo salvelinus*, which were hatched from the eggs sent to me by Mr. Livingston Stone. (I did not get a fish from the eggs which you sent me.) They are now from 6 inches to 8 inches long and resemble our brook trout (*Salmo fontinalis*) very much. I have examined them very closely and compared the two fishes together, and I fail to see any difference in their general appearance. I think they will spawn next November.

OLD COLONY TROUT PONDS,
Plymouth, Mass., April 24, 1882.

INQUIRIES CONCERNING THE PROPAGATION OF AMERICAN SMELT AND SHAD, AND NOTES ON THE FISHERIES OF THE WASH IN ENGLAND.

By CHARLES W. HARDING, Inspector of Fisheries in the Wash.

[Letter to Prof. S. F. Baird.]

I am requested by the corporation of King's Lynn to report upon what I consider the best method of restocking the river Ouse with smelts and other anadromous fish, and shall feel greatly obliged if you will give me the following information:

I see by the printed reports of the United States Commission of Fish and Fisheries (which you were kind enough to send me in 1880), that the smelt is there called *Osmerus mordax* and *Osmerus viridescens*. The English or *sparling* being called *Osmerus eperlanus*—the word "sparling" is a local name for the smelt. Is the American smelt the same as the English smelt?

I see by the report of the Commissioner of Fisheries of Maryland, January, 1877, that the attempts at artificial propagation of smelts were unsuccessful. I have not been able to obtain any subsequent reports to see if it has since been so.

Smelts spawn in this river (Ouse) from April to the beginning of June, and I am anxious to know if it is possible to obtain the ova either from the fish direct, or from the spawning-ground, and hatch it out in gauze trays or troughs, and whether fresh water will do, or is it necessary to have the water partly salt.

I also observe in your reports that the shad is largely hatched artificially for the American rivers, the method of hatching being explained in detail. Smelts are indigenous to this river, and I am of opinion that the artificial propagation of them in large quantities would be beneficial to the fisheries. May I ask if the shad (which I was informed by Mr. Fred. Mather, at Berlin last year, was different from the English shad) would be the most desirable fish to cultivate in these waters, or would you recommend another anadromous fish?

The river Ouse is about 500 feet wide at its entrance into the Wash, running between the counties of Norfolk and Lincolnshire. The main stream is about 156 miles in length, draining an area of about 2,890 square miles, with a tidal flow of about 40 miles from its outfall. The Wash, into which the Ouse empties itself, is, as you doubtless know, an arm of the North Sea, or German Ocean, on the east coast of England, about 16 miles long by 10 miles (an average width). The saltness of the Wash water, or rather the specific gravity, is 1026½ at high water. The average (specific gravity) at the mouth of the Ouse, at high water, is about 1010 hydrometer; distilled water being 1000.

In the Wash, about fifty years ago, were enormous oyster beds; one extending nearly the whole length of the Wash and continuing outside about 50 miles. One bed in particular, which was discovered about forty years ago, being (as the fishermen state) a fathom and a half deep, with nothing but oysters. Now everything is changed; the oysters on these beds are nearly exhausted, there not having been a fall of spat for a great number of years, owing, I believe, to the low temperature of the summers, the temperature of the last twelve years not having exceeded 62° Fahr., generally under 59°, of the waters of the Wash.

The Wash is, or should be, the natural nursery for shrimps, soles, flounders, and other flat fish, but owing to the incessant practice of catching shrimps all the year round with small-meshed trawls, the mesh being barely capable (when strained) of letting a wire through, this fishery is at a very low ebb.

KING'S LYNN, ENGLAND,
April 21, 1882.

DISEASE AMONG THE SALMON OF MANY RIVERS IN ENGLAND AND WALES.*

By S. WALPOLE AND PROF. T. H. HUXLEY.

We desire to draw attention to the remarkable outbreak of a disease among the salmon of many rivers. The disease was noticed originally in the autumn and spring of 1877 in two rivers, the Esk and the Nith, which flow into the Solway Firth. It soon spread to the Eden and other adjoining rivers. In the spring of 1879 it was observed in the Tweed, when it rapidly became very serious, and in 1880, when a commission was appointed to investigate it, it had extended to the Nith, the Annan the Esk, the Eden, the Cree, and the Dee, all flowing into the Solway Firth; to the Doon and the Ayr in Ayrshire; to the Derwent in Cumberland, the Lune in Lancashire, and to the Tweed. Since then the disease has broken out in the Seiont, the Ogwen, and the Conway in North Wales, and in the Tay and North Esk in Scotland.

We have very little doubt that the disease, which first excited attention in 1877, had existed, at any rate in a sporadic form, for many years. It was stated in evidence before the late commission that Dr. Crosbie, formerly surgeon to the Challenger expedition, carefully investigated a case of the disease so long ago as in 1852. His observations will be found in the Commissioners' Report, p. 44. Other witnesses similarly

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*Reprinted from a pamphlet entitled: Twenty-first Annual Report | of the | Inspectors of Fisheries (England | and Wales.) | (For the year 1881.) | Presented to both Houses of Parliament by command of Her Majesty. | London: | Printed by George E. Eyre and William Spottiswoode, | Printers to the Queen's Most Excellent Majesty. | For Her Majesty's Stationery Office. | 1882. |

stated to the commissioners that they had observed sporadic cases of the disease for years. We may add that we have recently understood from a lessee of fisheries on the North Esk that he had seen disease, fish, without recognizing them as diseased, for very many years; and we have very little doubt that sporadic cases of the disease occur in almost every river.

The first symptom of this disease is the appearance of small grayish or ashy discolorations of the skin, usually upon those parts of the body which are devoid of scales, such as the top and sides of the head, the delicate valvular membrane on the inside of the jaws, the adipose fin, and the soft skin at the bases of the other fins. Where such discoloured patches occur on the scaly parts of the body the scales are hidden by a film, and it might readily be supposed that they had been detached. But if the discoloured film is gently washed or wiped off, the scales will be found beneath perfectly undisturbed. On the scaleless part of the body, also, the discoloured places often look as if they were the effect of bruises or abrasions, but careful examination of the skin fails to reveal any evidence of external injury.

The exact character of this affection of the skin may best be observed in the recently formed isolated patches, not bigger than a sixpence, in which the disease appears on the soft integument of the head. Such a patch is usually nearly circular, and has a well-defined margin separating it from the healthy skin. The central region of the patch is somewhat raised and more discolored than the rest, and faint ridges may commonly be seen radiating from it, through the marginal zone, to the edge of the patch. A single patch of this character may be observed on a fresh-run fish, which, from its activity, the excellent condition of its flesh, and the perfectly normal aspect of its internal organs, shows itself otherwise to be in full health.

When a patch of diseased skin has once appeared, it rapidly increases in size and runs into any other patches which may have appeared in its neighborhood. The marginal zone, constantly extending into the healthy surrounding skin, retains its previous characters, while the ashy central part changes. It assumes the consistency of wet paper, and can be detached in flakes, like a slough, from the skin which it covers. If the subjacent surface is now examined it will be found that the *epidermis*, or scarf-skin, has disappeared, and that the surface of the vascular and sensitive *derma*, or true skin, beneath, is exposed. As the diseased area extends, the papyraceous coat more and more completely takes the place of the epidermis, until, in extremely bad cases, it may invest the back and sides of a large salmon from snout to tail.

The affection, however, is not confined to the epidermis. As the patch acquires larger and larger dimensions, the derma, or true skin, in its centre becomes subject to a process of ulceration; and thus a deep, bleeding sore is formed, which eats down to the bones of the head and sends off burrowing passages, or sinuses, from its margins.

In severe cases, the skin of the top of the head, of the snout, of the gill covers, and of the lower jaw may be almost completely destroyed, and the affection may extend far into the interior of the mouth. Cases of the blinding of fish by extension of the disease over the eyes are reported. It is also said that the gills are attacked; but, although careful attention has been paid to this point, the gills have been unaffected in every fish that has come under our notice, however severe and extensive the disease might be. In far-advanced cases the edges of the fins become ragged; and, sometimes, the skin which invests the fin rays is so completely destroyed that they stand out separately.

All observers agree that the flesh of a diseased salmon, however extensive the morbid affection may be, presents no difference in texture, or in color, from that of a healthy fish; and those who have made the experiment declare that the flavour of a diseased fish is as good as that of a healthy one. No morbid appearances are discoverable either in the viscera or in the blood. Moreover, when fresh-run fish are diseased, they may exhibit just as large an accumulation of peritoneal fat as healthy fish. Nevertheless, it is certain that the cutaneous affection causes much irritation. The fish exhibit signs of great uneasiness, often dashing about and rubbing themselves against stones and other hard bodies in the water. Eventually they get weaker, become sluggish, and often seek the shallows before they die.

The disease spreads with great rapidity after it has commenced, three or four days being said to be sufficient to enable it to extend over the whole body of a large salmon.

In the early stages of the malady, the peculiar appearance of the parts of the skin affected might readily be, and certainly often has been, ascribed to mechanical injury. It has already been remarked that the scales often appear to have been detached when in reality they are only hidden by the pellicle which covers them; nor, so far as inspection with the naked eye goes, is there anything to suggest that the disease, in its most advanced form, is anything but a sloughing ulceration of the skin. But, when the papyraceous substance which constitutes the apparent slough is subjected to microscopic examination, it proves to be something totally different from mere dead tissue of the fish, such as a true slough would be. In fact, the comparison with wet paper turns out to be more exactly correct than might have been anticipated; for, like wet paper, it is chiefly composed of a felted mass of vegetable filaments, intermixed with which are *débris* of the tissues of the skin of the salmon and all sorts of accidental impurities; especially shells of Diatoms and multitudes of very minute sand grains, derived from the water in which the salmon swim. The filaments vary in thickness from $\frac{1}{600}$ of an inch to $\frac{1}{3000}$ of an inch, the majority lying between $\frac{1}{3000}$ and $\frac{1}{2000}$ of an inch. Each filament is tubular, composed of a thin wall, which contains cellulose, or the essential proximate principle of wood, lined by a thicker or thinner layer of finely granular protoplasm, within which, again, is a watery fluid. The whole filament is colorless and usually transparent,

but sometimes the granules are sufficiently numerous to render it opaque; and then it looks white by reflected light. Sometimes the filaments are simple as far as they can be traced; sometimes, on the other hand, they are much branched; but they never exhibit any transverse partitions, the cavity of each filament being continuous throughout. Wherever the free end of a filament is to be seen it is rounded, closed, and often no larger than the rest; or the filament may taper to its extremity. But the free ends of a greater or less number of the filaments are slightly enlarged, so as to be club-shaped, or they may be pyriform, or even almost spheroidal, and the layer of protoplasm which they contain is very thick. The cavities of some of these enlarged ends are shut off by a transverse partition from the rest of the filament, thus giving rise to a closed case. In others the protoplasm is broken up into a number, greater or less, according to the size of the enlargement, of equal-sized spherical masses, each rather less than $\frac{1}{2000}$ of an inch in diameter, which lie separate, but closely packed in the interior of the case, like shot in a cartridge. (Fig. I, p. 433.) In others the case is seen to be open at the end, and a portion or the whole of the "shot" have passed out. In yet others, again, a full unopened case is seen to lie inside an empty one.

The papyraceous mass is, in fact, what is known as the *mycelium* of a fungus. It answers exactly to the similar, wet-paper like, crust which is formed by the common fungus, *Penicilium glaucum* (usually known as "blue mould"), on the surface of a pot of jam. The filaments are the stems of the fungus, and are technically known as *hyphæ*. The enlarged ends of the hyphæ, which are converted into the "cases," are the *sporangia*, or fruits of the fungus, and they are termed *zoosporangia*, inasmuch as the spheroidal bodies or *spores*, under certain circumstances, are actively locomotive, after the fashion of many animalcules, and are therefore termed *zoospores*. It is a peculiarity of this particular fungus that, when a zoosporangium has emptied itself, the hypha on which it is supported begins to grow afresh, sends a prolongation through the centre of the empty sporangium, and dilates into a new one within or beyond it. Hence the appearance of a full sporangium, surrounded by one, or it may be two or three empty ones, one inside the other. (Fig. II, p. 433.)

This structural feature is peculiar to the genus *Saprolegnia* among fungi, and it enables mycologists to identify the fungus, of which the papyraceous incrustation characteristic of the salmon disease is a product, as a species of that genus.

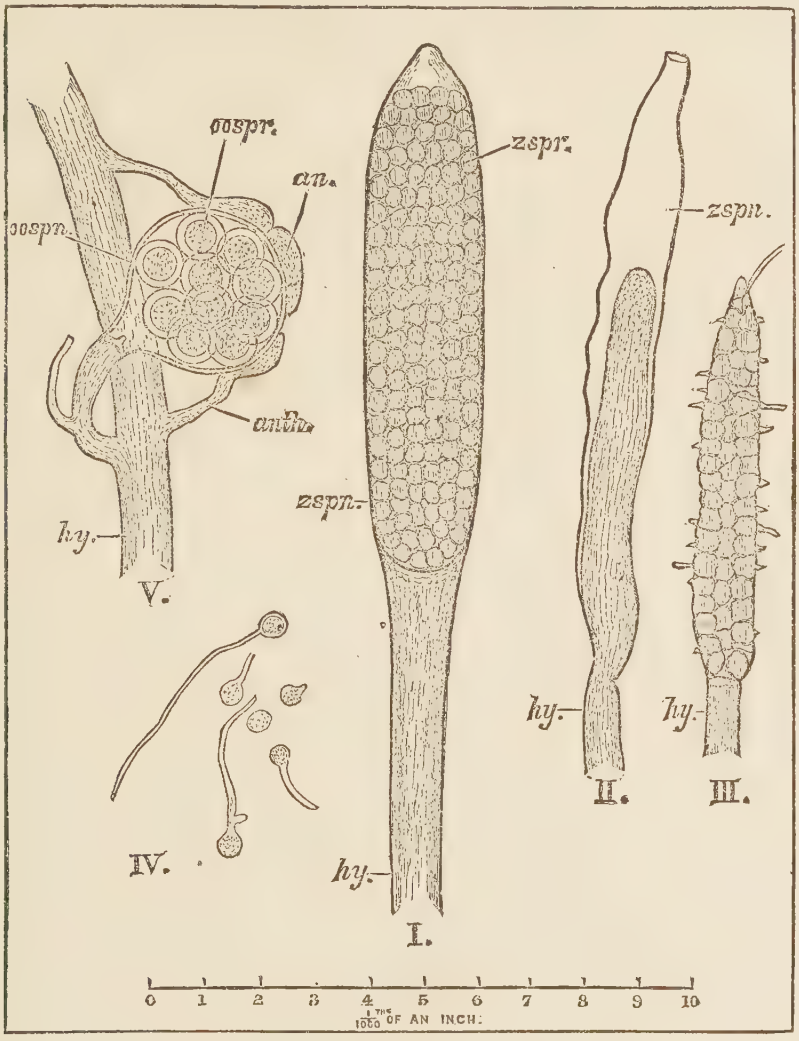
Thanks especially to the labors of Pringsheim,* Cornu,† DeBarry,‡

* "Die Entwickelungs-geschichte der Achlya prolifera." Nova Acta, 1851, and several later papers in the Jahrbücher für Wissenschaftliche Botanik for 1857, 1860, and 1874.

† "Monographie" Annales des Sciences Naturelles, Botanique, 1872.

‡ De Barry and Woronin. "Untersuchungen über die Peronosporeen und Saprolegnien," 1881.

and Brefeld,* a great amount of accurate information respecting the *Saprolegniæ* has been accumulated of late years.



CHARACTERISTIC FORMS OF THE SPORANGIA AND SPORES OF SAPROLEGNIA.

I.—A zoosprangium full of nearly ripe zoospores from the skin of a living diseased salmon.

II.—An empty zoosporangium, through the center of which the hypha is growing in order to produce a new zoosporangium. From the fresh growth of *Saprolegnia* on the diseased jaw membrane of a salmon, cut off and placed in water.

III.—A dictiosporangium from salmon *Saprolegnia* cultivated on a dead fly. The spores have remained in the interior of the zoosporangium, and, after encasing themselves, have there germinated.

IV.—Zoospores of salmon *Saprolegnia*, germinating in water.

V.—An oosporangium of *Saprolegnia* from the pike, cultivated on a dead fly. The oosporangia of the salmon fungus in all respects resemble this.

Signification of the letters: *hy*, hypha; *zspn*, zoosporangium; *zspr*, zoospore; *oospn*, oosporangium; *oospr*, oospore; *anth*, antheridial filament; *an*, antheridium.

* Botanische Untersuchungen. Heft IV, 1881, pp. 109. 110.

They may be defined as a kind of water-moulds, which usually live at the expense of dead and submerged animal and vegetable substances, and are especially common upon dead insects and other invertebrate animals. Their delicate hyphæ form a white cottony fringe to such matters.*

A dead fly which has fallen into water is a favorite nidus for *Saprolegnia*, the hyphæ of which radiate from it in all directions, so that the fly appears to be inclosed in a pale white fluffy ball. Careful examination shows that such a fly represents the soil in which an immense number of the minute *Saprolegniæ* are implanted. One-half of each fungus consists of branching hyphæ, which answer, in a fashion, to the stem and branches of an ordinary plant, and are visible externally; the other half of the fungus corresponds, in the same general way, to the root and rootlets, the hyphæ ramifying in the interior of the fly, and the two parts being connected by a portion which traverses the dense cuticle with which a fly's body is coated.

The stem-hyphæ answer exactly in size and structure to the hyphæ of the salmon fungus. Moreover, a large number of them terminate in zoosporangia of the same character, which evacuate their zoospores, and are reproduced in the same way.

Flies, or parts of flies, such as the legs, on which *Saprolegniæ* are healthily growing, can be isolated and watched for any needful time under the microscope, so that the whole process of the formation of the zoosporangia and zoospores can be followed step by step. It may then be observed that the simple sub-cylindrical free end of a hypha enlarges, that protoplasm accumulates in it, and that its cavity finally becomes shut off by a transverse partition from the rest of the hypha, as a zoosporangium, the summit of which is usually slightly conical. The protoplasm is then seen to break up, simultaneously, into from eight or ten to a hundred and fifty zoospores, according to the size of the zoosporangium. The apex of the latter then opens and the zoosporangia are emitted. Each zoospore, as it leaves the zoosporangium, is usually in active motion, being propelled by the rapid lashing of two vibratile cilia which are attached to one point of its surface. After a few minutes it becomes quiescent and surrounds itself with an extremely delicate transparent coat. But this repose is of a very short duration, as it soon emerges from its envelope, and moves about even more actively than before. It has now an elongated oval shape, and has two cilia which proceed from one side of the oval. This second active state may last for a day, or perhaps two; and it is obvious that, from the activity of the motion of the zoospores, to say nothing of accidental currents, they may thus be carried a long way from the parent stock. Sooner or later, however, they again come to a state of rest, which is final, and they then usually germinate. That is to say, one, or perhaps two, delicate

* Whence the name σαπρός, *sapros*, rotten, and λίγνον, *legnon*, the edging of a garment.

filaments grow out and represent the primitive hyphæ of a new *Saprolegnia*. (Fig. IV, p. 433.)

If the spore has attached itself to some body which is incapable of affording it nourishment, it may not germinate at all, or if it germinates it speedily dies. But if it falls upon an appropriate soil, such, for example, as the body of another dead fly, the spore sends a prolongation inwards which perforates the tough chitinous cuticle of the fly, and gives rise to a system of root-hyphæ in its interior; while, simultaneously, it grows outwards into a similarly ramifying stem-hypha, the branches of which soon enlarge into zoosporangia and give rise to zoospores, as before.

The growth and development of the *Saprolegnia* take place with extraordinary rapidity. In 36 hours from the first infection of the body of a dead fly with the *Saprolegnia* spores, it may be covered with a thick coat of stem-hyphæ a fifth of an inch long; and in the course of the second or third day a thousand of these may have developed and emptied their sporangia, thus setting free some 20,000 zoospores, every one of which is competent to set up the same process in a new fly-corpse. As all this production takes place at the expense of the tissues of the fly, the supply of nutritive material gradually diminishes. At about the fourth day, or perhaps not till later, new forms of sporangia, termed "dictyosporangia," (Fig. III, p. 433,) in which the spores encase themselves and often germinate while still within the sporangium, make their appearance, and the ordinary zoosporangia diminish in number. Not unfrequently, about this time or subsequently, the hyphæ tend to break up into short joints which are themselves capable of germination. Finally, after the fifth or sixth day, a new kind of sporangium usually makes its appearance, which is termed an *Oosporangium*, inasmuch as the spores to which it gives rise are more like eggs or seeds than the products of the zoosporangia or those of the dictyosporangia.

The summit of a hypha, or a short branch of a hypha, dilates into a spheroidal sac, the cellulose wall of which becomes thickened, but presents here and there thin places, looking like clear circular dots or apertures under the microscope. Protoplasm accumulates in the spheroidal case thus formed, and either remains a single rounded mass, or divides into a smaller or greater number of spheroids, each of which, much larger than a single zoospore, is an *Oospore*. The oospore or oospores thus formed eventually become invested by a thick cellulose coat. Before this happens, in some forms of *Saprolegnia*, slender twig-like branches are given off either from the stalk of the oosporangium or from an adjacent hypha, and the terminal portion of one or more of these twigs applies itself to the oosporangium. This terminal portion becomes shut off from the rest of the twig by a transverse septum, and is an *Antheridium*. The antheridium pierces the wall of the oosporangium, divides into as many branchlets as there are oospores, and one branchlet applies itself to each oospore. In all probability something

passes from the antheridium into the oospore, and effects fecundation. (Fig. V, p. 433.)

Thus the oosporangium represents a female reproductive organ, and the oospore takes the place of an egg or an embryo cell. The antheridium represents a male organ, and its contents represent the essential substance of spermatozoids or the fertilizing matter of a pollen tube; and, after fecundation, the oospores answer to impregnated ova or fertilized seeds.

The oosporangium may burst and give exit to the oospores, or it may fall with them to the bottom. And, as a general rule, the oospores remain for a long time, sometimes several months, unchanged. Sooner or later, however, they germinate, and this process may take place in various ways:

1. The contents of the oospore may divide directly into locomotive zoospores, which are set free.

2. The oospore may send out a hypha, the apical part of which becomes converted into a zoosporangium.

3. The oospore may send out a hypha, and this coming into contact with the body of a fly, or some such matter, may develope into a mycelium in the ordinary way.

The whole series of phenomena now described represents the fullest set of changes known to occur in any one form of *Saprolegnia*. But, even in the same form, the series may present notable variations. Thus, the zoospores may germinate without passing into an active condition; or they may germinate immediately after they assume the first quiescent state. Again, in one and the same form, antheridia are sometimes developed and sometimes absent. In some forms, indeed, anteridia never make their appearance, and consequently fertilization does not occur. Nevertheless, the unfertilized oospores germinate and produce new *Saprolegniæ*, apparently just as well as if they were fertilized.

The commonest species of *Saprolegnia* has received the name of *S. ferax*, and both Pringsheim and De Bary agree that several so-called species, namely, *S. monoica*, *S. thureti*, and *S. torulosa* are merely more or less permanent varieties of *S. ferax;* that they are all, in fact, members of the *S. ferax* group.

It has been seen that the fungus which grows on diseased salmon is unquestionably a species of the genus *Saprolegnia;* and it is commonly identified with *S. ferax*. But this identification has rested upon very slender grounds. It is practically almost impossible to determine the species of a *Saprolegnia* until the characters of its oosporangia and of its antheridia (if it have any) have been accurately made out. At present, not only are we without any sufficient account of these organs in the salmon *Saprolegnia*, but it is certain that they are, at most seasons, extremely rare. Mr. Stirling* speaks of having observed only four in

*Mr. Stirling's valuable contributions to our knowledge of the salmon disease are contained in the "Proceedings of the Royal Society of Edinburgh" for 1878 and 1879.

the course of all his investigations; and not a single specimen has presented itself in the considerable number of diseased salmon from the Conway, the Tweed, and the North Esk, which have come under our observation during the last four months.

When our inquiries commenced, there was, strictly speaking, no proof that the salmon *Saprolegnia* could live on anything but a salmon. It was, therefore, quite possible that, since there are many species of *Saprolegnia*, that of the salmon might be peculiar to it, just as, in the analogous case of the potato disease, *Peronospora infestans* is different from all the species of *Peronospora*, which abound upon European wild plants, and will not live on them any more than these other species will live on the potato.

However this may be, it is easily proved that the *Saprolegnia* is not dependent on living salmon. In fact, if a patch of diseased skin is cut off and placed in a vessel of water it will be found in twenty-four hours to be covered with a new growth of young hyphæ, close set, and of nearly equal lengths, so that the surface resembles a miniature cornfield. A piece of the diseased membranous valve of the mouth of a salmon was placed in water on the 4th of March, 1882; on the 6th it was covered with young hyphæ one-fifth of an inch long; and on the 7th these had elongated and developed multitudes of zoosporangia.

Moreover, there is not the least difficulty in proving that the salmon *Saprolegnia* is not dependent upon salmon at all, but that it is capable of living on dead insects and pieces of wet bladder. If a recently killed fly is gently rubbed two or three times either over a fresh patch of diseased salmon skin, or over one which has developed the fresh growth just mentioned, and then placed in a vessel of water by itself, it will be found in the course of eight-and-forty hours to be more or less extensively beset with short delicate cottony-looking filaments, which rapidly increase in length and in number until, at last, the fly's body is inclosed within a spheroidal coat half an inch in diameter. These filaments are hyphæ having exactly the same size, form, and structure as those of the salmon *Saprolegnia;* their ends give rise to zoosporangia of the same character; and these produce zoospores of the same size, which germinate in the same way.

Between December, 1881, and April of the present year, repeated experiments of this kind have been made with diseased salmon from the Conway, the Tweed, and the North Esk, upon dead flies, and small pieces of wet bladder, always with the same result. There appears, therefore, to be no doubt that the *Saprolegnia* of the salmon, like other

Mr. W. G. Smith, in a paper on the salmon disease in the "Gardener's Chronicle," May 4, 1878, not only affirms that "the resting spores are common enough," but figures them. However, Mr. Smith's figures of the zoosporangia are so unlike anything ordinarily observed in the salmon *Saprolegnia*, and his statement that "the fungus has invariably vanished with the death of the fish," is so strangely contrary to common experience, that it is difficult to know how much weight ought to be attached to his observations.

Saprolegniæ, is capable of living and flourishing on a variety of dead animal matters.

When the *Saprolegnia* is established on one such substance it is easy to transmit it to another. The *Saprolegnia* obtained from diseased salmon was thus cultivated for many weeks (from the end of December, 1881, to the first week in April, 1882) in the hope of obtaining the oosporangia and thus identifying it with one or other of the described forms of the *S. ferax* group. Up to the last-mentioned date, however, no oosporangia appeared on any of these cultures. The course of events was this: for two or three days zoosporangia were very abundant, and thousands of zoospores were set free. But in no case which came under observation for several months were these zoospores provided with cilia, or actively locomotive. They were discharged from the zoosporangia as simple spherical corpuscles, which flowed passively away, and were very often seen germinating by sending out a single delicate hypha. Immense numbers of these spores accumulated among the hyphæ.*

After this condition had lasted for a day or two, the ordinary zoosporangia diminished in number, and "dictyosporangia" made their appearance in place of them. In other words, the spores, instead of being discharged, were retained within the zoosporangium, and began to germinate in that position.

At the same time, the protoplasm accumulated in certain regions of the hyphæ, which often became swollen, and these accumulations were shut off from the rest by transverse partitions. The hyphæ thus assumed a jointed or beaded appearance, as in the *S. torulosa* of De Bary, and the joints might eventually separate from the intervening empty parts of the hyphæ, as a sort of buds or *gemmæ*, which, after detachment, might begin to germinate by throwing out delicate hyphæ at one or many points. Sometimes these buds were terminal and spheroidal and closely simulated oosporangia, but they did not give rise to oospores. No trace of antheridial branchlets was ever visible.

In the third week of April, however, oosporangia and antheridia, in all respects similar to those of the "*monoica*" form of *Saprolegnia ferax*, made their appearance in a copious growth of the fungus on a fly, which was infected on the 24th of March from a culture on bladder, which was

* Among previous observers, Mr. Stirling and Mr. W. G. Smith describe and figure locomotive zoospores as if they were of ordinary occurrence. Mr. Brook, on the other hand ("Notes on the Salmon Disease in the Esk and Eden." Transactions of the Botanical Society of Edinburgh, 1879), appears never to have seen locomotive zoospores; and Mr. George Murray, of the Botanical Department of the British Museum, who has been kind enough to make a series of observations and experiments, continued over six or seven weeks, on crops of *Saprolegnia*, raised upon dead flies infected from Conway salmon, has met with the same negative results. Quite recently, however (March 16), locomotive zoospores have been emitted from one of our specimens of salmon fungus cultivated on bladder. But, as in our specimens, so in those cultivated by Mr. Murray, no trace of oosporangia had appeared up to that time.

again derived from a fly, infected directly from a North Esk salmon on the 14th of March.

It may be safely concluded, therefore, that the salmon fungus is not a parasite peculiar to that fish, but that it is a form of the *Saprolegnia ferax*, which, so far as our observations go—and it must be remembered that these extend over only the quarter of the year between Christmas and the spring equinox—remains devoid of oosporangia so long as it infests the fish, and tends to persist in this condition for a long time, even when it is cultivated on those matters upon which the *Saprolegnia* more usually subsists. Further observation must determine whether oosporangia are developed on the *Saprolegnia*, while still growing on salmon, later in the year. The evidence of the fact at present extant is extremely unsatisfactory; and it is a remarkable circumstance that the figures which have been published show no trace of antheridial filaments.

That living fish may be attacked and destroyed by epidemic diseases, of which a *Saprolegnia* is either the cause or the constant accompaniment, has been known for a very long time.

Forty years ago the eminent German botanist, Unger,* described a disease which broke out among some carp in a pond in the Botanic Gardens at Gratz, and was obviously caused by a fungus, at that time known as *Achlya prolifera*, but which the description and figures given by Unger clearly prove to belong to the genus which is now distinguished as *Saprolegnia*, and indeed to be very similar to, if not identical with, *S. ferax*. More or less distinctly circumscribed pale spots appeared upon the skin of the back and of the fins. The fish became sluggish, and sought the surface of the water. A velvety investment, formed of very delicate colourless close-set threads, showed itself on the spots affected, which rapidly became confluent, and extended from mouth to anus, and even on to the gills. The scales of the affected parts became detached, red, and swollen, and sometimes ulceration occurred. The animals could no longer move without appearing to suffer great pain; they remained at the surface of the water, lying either on their backs or on their sides; and death took place in eight-and-forty hours. Unger found that the disease could be transferred to perch by inoculation.

Again, there seems no reason to doubt that the fungus which accompanied the epidemic disease affecting roach, dace, gudgeon, small pike, and perch, at Ightham in Kent, of which a very full and interesting account is given by Mr. Stirling,† is to be referred to *Saprolegnia ferax*. Here, however, ulcerative destruction of the skin does not appear to have occurred, and the mortality is said to have arisen from suffocation, the fungus obstructing the respiratory passages.

Pike kept in aquaria not unfrequently become covered with a fungus.

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*"Sur l'Achlya prolifera." Annales des Sciences Naturelles. Botanique. Serie III. 1844.

†"Additional Observations on Fungus Disease of Salmon and other Fish." Proceedings of the Royal Society of Edinburgh. X., 1879.

The fish do not appear to be inconvenienced, and the fungus is very easily washed off. In a case of this kind which we recently examined, the fungus was a *Saprolegnia*, the mycelium and the zoosporangia of which were altogether indistinguishable from those of the salmon fungus. Moreover, the hyphæ burrowed in the epidermis and distorted the cells with which they came in contact in just the fashion described below (p. 442). As it was not desirable to kill the fish, it was impossible to determine whether the derma was penetrated or not; but the absence of sores, and the ease with which large flakes of epidermis, in which the *Saprolegnia* was rooted, could be detached, lead to the conclusion that the *Saprolegnia* had not penetrated beyond the epidermis. The zoosporangia of the *Saprolegnia* taken from the fish emitted actively locomotive zoospores, but no oosporangia could be detected.

Dead flies, infected with this *Saprolegnia* on the 18th of March, 1882, yielded an abundant growth, quite similar to that obtained in the same way from the salmon *Saprolegnia;* and on the 24th, that is in six days, the characteristic oosporangia and antheridia of *Saprolegnia ferax* (*monoica*) made their appearance.

It appears, therefore, that *Saprolegnia ferax* is capable of attacking a great variety of fishes during life, but that the concomitant pathological phenomena differ in different fishes.

Mr. Stirling's experiments on the transmissibility of the salmon fungus to other fish yielded only negative results. Diseased salmon skin was put into a vessel containing minnows, which nibbled the skin, and were none the worse. Experiments of this rough and ready sort, however, really prove nothing; and a great deal of light will assuredly be thrown upon the whole question of the salmon disease by carefully conducted experimental investigations.

At the present moment, we possess evidence that at least three distinct affections of the skin of fresh-water fishes have been confounded together under the name of "Aquarium fungus." One of these is associated with a *Saprolegnia* identical with that which attacks salmon; another is attended by the very closely allied fungus, *Achlya;* while the third is not accompanied by the growth of any fungus, but is a very curious morbid affection of the skin itself, apparently allied to epithelioma. We have hitherto observed it only in carp, the head, body, and fins of which sometimes appear covered with white patches, which present a most deceptive resemblance to those caused by *Saprolegnia*, the more especially as the edges of the fins may be eroded, and ragged fragments hang from the white patches. These patches, however, contain no fungus, but result from the abnormal growth of the epidermis, sometimes to eight or ten times its ordinary thickness, not unfrequently accompanied by a corresponding elongation of the papillæ of the derma.

Having thus dealt with the question of the nature and affinities of the fungus which is the constant concomitant of the "salmon disease," the

next point of consideration is the relation of the fungus to the affection of the skin. Is the growth of the fungus the cause of that affection, or does the fungus merely find a favorable nidus in the products of the affection?

The *Saprolegniæ*, as we have seen, habitually grow on dead animal and vegetable substances; and it is therefore a fair supposition that some morbid affection may cause the local death of the skin of the fish; and that the fungus simply implants itself in the dead tissue, as if it were the dead body of a fly.

On the other hand, our knowledge of the destructive epidemics caused by *Empusa* in flies, *Botrytis* in silkworms, and *Entomophthora* in other caterpillars, and of the multifarious fungi which produce bunt, smut, and mildew in plants, affords at least equal ground for the supposition that the ulceration and destruction of the skin are caused by the invasion of healthy fish by the *Saprolegnia*. The decision of this question is obviously of the greatest importance.

Direct experimentation by infection of healthy salmon, in the manner in which dead flies were infected from the diseased salmon, being out of the question, at present, on account of its practical difficulties, the only profitable way of investigation lay in the study of the minute structure of the healthy and of the diseased skin, so as to ascertain the exact relation of the fungus to the morbid appearances.

The skin of the salmon, like that of vertebrated animals in general, consists of a superficial, cellular, non-vascular, scarf skin, or *epidermis*, covering a deep fibrous and vascular true skin, or *derma*. The former is divisible into a superficial, a middle, and a deep layer of cells, the last being in immediate contact with the derma. The deep cells are vertically elongated, the middle ones more or less broadly spindle-shaped or rounded, while the thin superficial layer consists of flattened cells. The deep cells are constantly multiplying by fission, and their progeny become middle cells, the outermost of which, for the most part, becoming flattened, give rise to the superficial layer, which is continually shed and replaced. Some of the cells of the middle layer, however, enlarge, take on a more or less spheroidal form, and become filled with a mucous fluid. As they rise to the surface, they open and pour out this fluid, which lubricates the surface of the fish. In any vertical section of a properly prepared portion of salmon skin more or fewer of the openings of these cells are to be seen. The derma is composed of matted bundles of connective-tissue, traversed by blood-vessels and nerves, and containing numerous lymphatic spaces. The superficial layer of the derma contains a number of dark pigment cells, of which there is a close-set zone immediately beneath the epidermis.

In a thin vertical section of the skin of the head of a salmon, which has passed from the sound skin through the centre of a diseased patch, the various structural elements which have been described, disposed with great regularity, are alone visible in the healthy part of the sec-

tion. But, on advancing within the margin of the diseased area, hyphæ of the *Saprolegnia* are seen to penetrate horizontally between the cells of the middle layer, thrusting them asunder with so much force that the cells become bent and distorted, and adhere to a hypha as if they were spitted on it. And, in fact, it is because bundles of such hyphæ are thrusting themselves in this manner, as the roots of an ordinary plant thrust themselves into the soil, between the epidermic cells, that the radiating ridges which appear on the marginal area of the diseased patch are formed. Close up to the free ends of these hyphæ, however, the epidermis is perfectly healthy; and this fact suffices to prove that the growth of the fungus is the cause of the morbid affection of the epidermis, and not its consequence.

Proceeding further towards the centre of the diseased patch, the hyphæ become more numerous and take a vertical as well as a horizontal direction. Of the vertical ones, some traverse the epidermis outwards, thrusting aside and disturbing its cells, and terminating in short free ends on the surface. Others of the vertical hyphæ, on the contrary, are directed inwards; and, as root-hyphæ, not only traverse the deep layer of the epidermis, but pierce the superficial layer of the derma, and penetrate into its substance for a short distance. Yet nearer the centre, the epidermis is completely broken up into fragments and detached cells, which lie in the meshes of the thick mycelium formed by the horizontal and vertical stem-hyphæ of the fungus. The vertical stem-hyphæ attain their full length, often branching, and begin to develope zoosporangia. Towards the derma, the root-hyphæ are so numerous and close-set that they are often separated by interspaces which hardly exceed their own diameter, where they penetrate the superficial layer of the derma. Moreover, they branch out in the latter to a depth of a tenth of an inch, often penetrating the bundles of connective-tissue. Their ultimate ramifications usually end in curiously swollen extremities. Still more towards the centre of an ulcerated patch, the place of the epidermis is taken by the felted mycelium of the *Saprolegnia*, the superficial layer of the derma has disappeared, small vessels have often been laid open, and blood has been effused.

All these appearances become perfectly intelligible, if we suppose that, when *Saprolegnia* spores reach the surface of the body of a live salmon, they behave in the same manner as we know they do when they reach the surface of the body of a dead fly. If it should light upon one of the apertures of the mucous cells, an easy road into the soft interior of the epidermis is open to the hypha of the germinating spore. But, apart from this, the flat superficial cells are certainly as easy to pierce as is the tough cuticle of a fly. No doubt, as in the fly, the hypha grows directly inwards, and piercing the superficial layer of the derma, comes into direct relation with the abundant nutriment it finds there. The fungus then ramifies, on the one side, in the derma, on the other in the epidermis, sending off, in the latter, vertical branches which soon

develope sporangia, and horizontal branches, which are driven, like subsoil ploughs, into the middle layer of cells. The zoosporangia emit multitudes of zoospores, many of which are deposited on the epidermis in the neighborhood of the first; and, penetrating it in the same way, add to the *Saprolegnia* plantation. Thus the disease constantly spreads centrifugally; and, as the oldest and most luxuriant growth of *Saprolegnia* is in the centre, so is the mechanical destruction of the epidermis first effected there. But it is in this region, also, that the greatest number of root-hyphæ penetrate the derma. They cannot fail to interfere with the nutrition of the tissues which they traverse; in fact, their ramifications are often so close-set that the proper tissues of the superficial layer of the derma almost disappear. Sooner or later, therefore, necrosis sets in, and then ulcerative sloughing takes place, resulting in an open sore. No doubt the morbid process thus described is accelerated and intensified by the irritation caused by the innumerable small grains of sand and other foreign bodies entangled by the mycelium. But that the primary cause of all the mischief is the parasitic fungus does not appear to be open to doubt. If it were otherwise, the structural alteration of the skin should precede the fungus and not follow it, as it actually does.

In fact, the *Saprolegnia* is the cause of the salmon disease exactly as the closely allied fungus *Peronospora* is the cause of the potato disease. In symptoms, progress, and results, there is the closest analogy between the two maladies. *Peronospora*, like *Saprolegnia*, gives rise to spores which may be ciliated and actively locomotive, or may germinate without passing through an active stage. When these spores germinate on the surface of a healthy potato plant, their hyphæ perforate the walls of the cells with which they are in contact, and then ramify, as a mycelium, in the inner substance of the plant, carrying destruction wherever they go. The mycelium gives off hyphæ which pass through the stomates to the surface; and there they throw off abundant spores, which repeat the process until the whole plant is destroyed. Even the tubers are invaded; but, in them, the mycelium becomes quiescent on the approach of the winter season, to break out again, in full vigour, if the tubers are planted in the following spring. Moreover, there is as much uncertainty about the occurrence of antheridia and oosporangia, and of any sexual method of reproduction, in the *Peronospora* of the potato, as in the *Saprolegnia* while it infests the salmon.

There is a great deal of reason to believe that the *Saprolegnia* growing on salmon is killed by salt water; and that the injured skin may heal and become covered with a new epidermis when a diseased salmon enters the sea. But the discovery that the root-hyphæ of the *Saprolegnia* ramify in the derma, where the sea water cannot reach them, raises a curious and important question. It becomes possible that a diseased salmon returning to the sea may regain a healthy epidermis and appear perfectly sound; but that, like a potato-tuber invaded by

Peronospora just before the approach of winter, the fungus in the derma may simply lie dormant, and be ready to spring into activity as soon as the fish returns to fresh water. Cases of the appearance of the disease in quite fresh-run fish are occasionally reported, which would be readily explicable should this supposition turn out to be well founded.

Another possibility was suggested by the same fact. We know that the spores of the *Empusa*, a fungus which attacks living flies, germinate and bore through the cuticle in much the same fashion as the *Saprolegnia* enters dead flies. But the hypha of the *Empusa*, which has thus entered the fly, immediately breaks up into short joints, which diffuse themselves through the body of the fly and everywhere multiply by division, until they have appropriated all the nutritious matters which are available to them. It was therefore justifiable, on analogical grounds, to suppose that the hyphæ of *Saprolegnia*, which had entered the derma of a salmon, might break up in a similar way; and that the segments might be conveyed through the lymphatic and blood vessels into all parts of the body, and either produce blood poisoning by a septic fermentative action, or develope centres of obstruction by lodgment in the narrower channels of the vascular system. However, there is no evidence to justify this suspicion. The hyphæ in the derma show no signs of division, nor have any toruloid bodies, or other structures that can be regarded as derivatives of *Saprolegnia*, been observed, either in the blood or in any of the viscera.

The salmon disease, in fact, appears to be a purely cutaneous affection; and the fish seem to die partly from irritation and consequent exhaustion, and partly, perhaps, from the drain on their resources, caused by the production of so large a mass of vegetable matter at their expense.

The opportunities for the investigations, the chief results of which have now been detailed, have arisen only during the last three or four months; and a great deal more time and attention must be devoted to the subject before it can be expected that many of the obscurities and difficulties which still hang about it can be cleared up.

It is needful to discover the conditions under which the fungus exists in those rivers which are infested by the disease when the full-grown salmon have deserted them; whether it lingers in isolated cases among the parr, trout, or the non-salmonoid fish; or whether it contents itself with the bodies of dead insects, and other dead animal, and perhaps vegetable substances; or whether, in the late summer, oosporangia may not be formed and give rise to oospores, which, as De Bary's experiments show, may have a dormant period of three or four months; that is to say, sufficient to preserve them till the next return of the salmon.

On all these points, persons conversant with the use of the microscope, who are resident in the neighborhood of salmon streams, might obtain information of great value, hardly to be procured in any other way.

Although all the evidence leads to the conclusion that the *Saprolegnia* is the immediate and primary cause of the salmon disease, and that, in the absence of the fungus, the disease never makes its appearance, however polluted the water may be, or however closely the fish may be crowded, yet in this as in other epidemics caused by parasitic organisms, the prevalence and the mortality of the malady, at any given time and in any given place, must be determined by a multitude of secondary conditions independent of the immediate cause of the disease.

In the case of the potato disease, it is well known that dry weather is extremely unfavourable to the growth and diffusion of the *Peronospora*. In such a season a plant may be affected here or there, but cases of disease are so rare that they escape notice. But if even a few days of rain with a thoroughly damp atmosphere supervene, the fungus spreads from plant to plant with extraordinary rapidity, and field after field is devastated as if struck by a sudden blight. So with the epidemic disorders of mankind. In a large town, isolated cases of smallpox, measles, diphtheria and the like constantly occur, and every case is the source of a vast quantity of infectious material. Nevertheless, it is only under certain conditions that this infectious material takes effect and gives rise to an epidemic.

At a moderate estimate, the *Saprolegniæ* on a single dead fly may carry a thousand zoosporangia. If each sporangium contains twenty zoospores, and runs through the whole course of its development in twelve hours, the result will be the production of 40,000 zoospores in the course of a day, which is a number more than sufficient to furnish one zoospore to the cubic inch of twenty cubic feet of water. Even if we have this rate of production, it is easy to see that the *Saprolegniæ* on a single fly may yield a sufficient abundance of zoospores to render any small and shallow stream, such as salmon often ascend for spawning purposes, dangerous for several days. For a single one of these spores, if it adheres to the surface of the skin of a salmon and germinates, is sufficient to establish the disease. Other things being alike, of course the greater the quantity of *Saprolegnia* in a stream the greater the chances of infection for the fish which enter it.

In looking for the causes of an epidemic of salmon disease we have therefore to inquire, in the first place, into the conditions which favour the growth of the *Saprolegnia*. It is known that the *Saprolegniæ* subsist not only on dead insects and on dead crustacea and mollusks, but on some other dead animal matters and on decaying plants. The particular form which infests the salmon, as we have seen, flourishes as well upon dead flies; it can also be grown upon pieces of bladder, but whether it can be transferred to decaying vegetable substances has yet to be determined.

Hence it follows that, within certain limits (active putrefaction appearing to be unfavourable to *Saprolegnia*), an increase of the quantity

of dead insects and other such organic matters in a river must tend to favour the growth and multiplication of any *Saprolegniæ* which it contains, and hence to increase the liability to infection of the salmon which ascend it.

And that this is no mere hypothetical deduction is very well shown by a remarkable case which was carefully investigated by Goeppert* nearly 30 years ago.

A peculiar water-mould, commonly known as *Leptomitus lacteus*, but which is so closely allied to *Saprolegnia* that Pringsheim places it in that genus, is widely spread in running waters, where it grows on all sorts of dead organic substances.

A factory for making a spirit from turnips was established near Schweidnitz in Silesia, and the refuse was poured into an affluent of the river Westritz, which runs by Schweidnitz. The result was such a prodigious growth of *Leptomitus* that the fungus covered some 10,000 square feet at the bottom of the stream with a thick white layer, compared to sheep's fleeces, choked up the pipes, and rendered the water of the town undrinkable. Scattered hyphæ of this *Leptomitus* may sometimes be found among those of *Saprolegnia*, growing on fresh-water fishes; and the two forms are altogether so similar, that conditions analogous to those which stimulate the growth of the one may safely be assumed to favor that of the other.

Brefeld has pointed out that there is no better medium for the culture of fungi of all sorts than an infusion of dung ("mistdecoct"). Land under high cultivation undoubtedly supplies the waters in its neighborhood with something that nearly answers to an infusion of dung; and this must be taken into account in discussing the possible factors of salmon disease.

Again, it is known with respect to many of the common moulds, such as *Penicillium* and *Mucor*, which are habitally *saprophytes* (that is to say, live on decaying organic matter, as *Saprolegnia* does), that they flourish in certain artificial solutions containing salts of ammonia. It is quite possible, though whether the fact is so will have to be experimentally determined, that *Saprolegnia* is capable of living under the same conditions. Fungi are also extremely sensitive to slight differences in the acidity or alkalinity of water, so that even apparently insignificant changes in this respect may come into play as secondary conditions of salmon disease. Hence, although there is not the slightest ground for regarding "pollutions," whether they arise from agricultural or from manufacturing industries, as primary causes of salmon disease, they may have a most important secondary influence; they may in fact determine whether, in any river, the disease shall be sporadic or epidemic.

But of all the conditions which determine the increase of *Saprolegnia*, and, therefore, multiply the chances of infection of healthy fish, the

* "Botanische Zeitung," XI, p. 163. 1853.

presence of already diseased fish is obviously one of the most important. A large fully diseased salmon may have as much as two square feet of its skin thickly covered with *Saprolegnia*, and its crop of spores may be taken as equivalent to that of several hundred flies. It may be safely assumed that 40 such salmon might furnish one spore to the gallon for all the water of the Thames which flows over Teddington Weir (380,000,000 gallons) in the course of a day.

In 1878, 350 dead salmon were taken out of a very small river, the Esk,* in three days. If the zoospores which these gave off had been evenly diffused through the water of the Esk, the difficulty is to understand how any fish entering it could escape infection.

In fact the objection easily arises that these arguments prove too much; and that, if the *Saprolegnia* is the cause of the disease, and its spores are thus widely diffused in an infected river, not a fish which ascends that river should escape the disease.

But such an objection loses its force if it is remembered that, though the *Saprolegnia* is the cause of the disease, and though a single spore is undoubtedly sufficient to kill a salmon; yet, in order to produce that effect, the spore must, in the first place, reach and adhere to the epidermis of the salmon; in the second place, it must germinate; and, in the third place, the delicate hypha which it sends out must bore its way through the epidermis into the derma.

Each of these conditions of successful infection may be modified in endless ways of which we know nothing—by the state of the epidermis of the fish; by the motility and the general vital energy of the spore; by the composition of the water, and especially by that of its gaseous and acid or alkaline contents.

To take only one of these conditions. If the spores germinate within the zoosporangia, or are not locomotive after they leave it, their chances of diffusion, and hence of reaching a healthy fish, will be vastly less than if they are locomotive, for even a short time. And again, their chances will be far less if they germinate after the first locomotive state, which lasts only a few minutes, than if they enter into the second locomotive state, which may endure for four and twenty hours or more. So, if the salmon *Saprolegnia* produces oosporangia in the late summer, and these lie dormant at the bottom until the following spring, the chances of infection of fresh-run fish will be greater than they will be if the continuance of the existence of the *Saprolegnia*, through the winter, depends upon the accident of a sufficient supply of dead organic substances.

Moreover, any one who has practised the cultivation of *Saprolegnia* is familiar with the difficulties which arise from the swarms of *Infusoria* and *Bacteria* which devour, or otherwise destroy, the fungus, notwithstanding all his efforts to preserve it.

The struggle for existence rages among fungi as elsewhere; and the

* Stirling, "Proceedings Royal Society of Edinburgh," vol. ix, p. 726.

question whether a salmon which enters water in which *Saprolegnia* is present shall be infected or not depends upon the mutual adjustment of a vast variety of conflicting agencies. Until we have learned something more than we at present know of these agencies, and of the history of the salmon *Saprolegnia* itself, there can be no thoroughly safe foundation for any view which may be put forward as to the best mode of dealing with the disease.

Nevertheless, since it is evident that every diseased salmon which remains in a river must immensely increase the chances of infection of the healthy fish in that river, the policy of extirpating every diseased fish appears, theoretically, to be fully justified. But whether, in endeavor to carry such a policy into effect in any given river, the cost would not exceed the loss from the disease, is a point which must be left for the consideration of boards of conservators.

We have the honor to be, sir, your obedient servants,

S. WALPOLE,
T. H. HUXLEY,
Inspectors of Fisheries.

The Right Hon. the SECRETARY OF STATE
FOR THE HOME DEPARTMENT.

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